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ANATOMY IN AMERICA

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ANATOMY IN AMERICA.*

INTRODUCTION.

For over a quarter of a century anatomical studies have been carried on in the biological laboratories of this university, important contributions to the science have been made, and students trained here have achieved notable success as teachers, physicians and investigators.[1] During the past year facilities for teaching and research work have been extended so as to include the study of human structure, and a department of anatomy has been created. The new department maintains, in addition to human anatomy, the work in vertebrate comparative anatomy, neurology, histology and embryology, previously carried on in the zoological department. It has been my pleasant privilege to be called here to share in the development of this new department, and it has seemed to me that it might be of interest to some of you who are engaged in other fields of science to consider with me briefly the growth of the science of anatomy, what America has contributed to this growth, and what we hope to see Wisconsin contribute toward it.

Anatomy has for its objects the determination of the facts and laws of the form and structure of organisms.[2] It is a fundamental biological science because, so far as is known, structure determines all vital activities and maintenance of structure is necessary for their existence. Life we see maintained by a vast number of plants and animals each of which has arisen by an orderly

*An address delivered before the Science Club of the University of Wisconsin, November 15th, 1904, with some additions and numerous explanatory notes. I desire here to express my obligation to many friends and especially to my colleague, Professor W. S. Miller, for aid in the preparation of these notes.

specific structural differentiation from a part of one, or the union of parts of two, similar pre-existing organisms, and each of which in turn may give off parts of its substance to be again differentiated into new individuals similar to itself. The lowest organisms, both animal and vegetable, merely divide into two or more portions, each of which soon assumes the form of the parent. The more complex organisms, on the other hand, through structural differentiation, give rise to special parts, destined, if fate permit, to be developed into new individuals. Thus, plants give rise to seeds, animals to eggs, and the power of a seed or an egg to develop into an individual like the parent, we have reason to assume is conditioned by its structure. The ultimate nature of the structure of living substance can at present merely be surmised. On the one side, the anatomist, by means of the microscope and a highly developed technique, seeks to penetrate deeper and deeper into its mysteries; on the other side, the chemist, by increasingly refined methods, investigates its nature. But between the two there is a vast and, as yet, impenetrable area.[3]

Yet, when one considers the vague and erroneous ideas of organic structure entertained by the people of unenlightened nations, and the unenlightened people of nations where science is cultivated, one cannot but be astonished at the vast amount of anatomical knowledge that has been accumulated since the science had its birth among the Greeks.

ANCIENT ANATOMY.

Aristotle, who in the fourth century B. C. summed up the anatomical knowledge of his time and added to it, had some curiously erroneous ideas concerning structure and function. The brain, he thought, could not be the organ of the mind, as some physicians asserted, because he found that, when exposed, the brain of a living dog did not seem sensitive to touch. He did not distinguish nerves from tendons or arteries from veins, and he thought movements brought about not by the action of the muscles but by the tendons and veins. The flesh he took as an organ of sensation. The distinction between arteries and veins and the functions of the brain, the nerves and the muscles, were discovered in the follow-

ing century by Herophilus and Erasistratus, who studied at the great school at Alexandria, where, for the first time, the human body was dissected. It is interesting to note that in this century lived Euclid, the mathematician, Aristarchus, the great astronomer, and Archemedes, the founder of mechanics. From the Alexandrian school sprang many generations of Greek physicians whom the spirit of inquiry led to make advance in anatomical science. The last great man among these was Galen, who lived in the second century A. D., who compiled much of the work of his predecessors, bettered it in parts, and in part put error where truth was known. His studies were conducted on apes and other mammals, but not on the human body. He treated the subject strictly from the teleological point of view.[4]

Curiously enough, although Galen is most severe in his criticism of those of his predecessors who took authority of man in place of authority of nature, which alone is to be trusted, he himself became the great authority on anatomy, physiology, pathology and medicine, for over thirteen hundred years. Ptolemy Claudius, a contemporary, performed a similar service for astronomy.

During the middle ages what little was known of anatomy was derived from Galen. With the revival of learning in Italy, renewed interest was taken in the subject. The awakening needs of art were added to those of medicine, and at the beginning of the fourteenth century human dissection was once more occasionally permitted. Mondinus at this time wrote a book on anatomy which remained a favorite for two centuries and a half. This book was not, however, based much upon personal observations, but was rather a compilation from books derived through the Arabians from the works of Galen. Mondinus' explanations of structure are often curious. Thus: "The skull is formed of discontinuous pieces so that the fumosities may escape through the sutures and the forces of medicine may reach the brain.[5]"

During the fourteenth and fifteenth centuries, however, some progress was made. By the end of the fifteenth a number of facts concerning human structure were known which were not found described by Galen, the original works of whom had mean-

while been discovered, circulated, and accepted as authorities in place of those of his Arabian commentators.[6]

RISE OF MODERN ANATOMY.

The times were ripe for a genius who could see all these new facts in their true relations and deliver anatomy from its bondage to the ancients. To Vesalius is chiefly due the honor of bringing this about. Three years before the death of Luther, and two after that of Paracelsus, in 1543, the year in which the epoch-making book *"De revolutionibus orbum cœlestum"* was put into the hands of its dying but immortal author, Copernicus, Vesalius published his great book *"De corporis humani fabrica libri septem."* This book is still of worth as a treatise on human anatomy. Its greatest value, however, lies in the fact that in it, for the first time, was shown the value of accurate objective study and good illustration. However theories vary, facts thus recorded are of permanent value.[7]

During the half century following the appearance of Vesalius anatomy reached its zenith in the Italian universities. To them students flocked by thousands from many countries. Medicine and law were the most favored studies, and human anatomy, as the basis of medicine, received high honors. This the beautiful theatres still existing at Bologna and Padua attest. Since the sixteenth century anatomy has not held relatively so high a place in Italy as at that period, but at all times, down to the present, Italian investigators have steadily advanced the subject and, from time to time, there has appeared a great man to force it far ahead.

From Italy the study of human anatomy spread to other countries. In Spain it found sterile soil and failed to flourish permanently. In France it suffered somewhat from the quarrels which there divided physician and surgeon, and long made its chief advances under royal support and protection at the *Jardin des Plantes*. In England it did not receive much university support and had to be cultivated chiefly in private schools by physicians in active practice, usually at great personal cost. Yet the path to

fame and position lay here, and England may well be proud of the great men who forced their way along its difficult course.[8]

It was, however, with anatomy as with painting. The world's chief centre shifted from Italy to the Netherlands. And, as in Italy, Leonardo da Vinci the artist, and della Torre the anatomist, Titian and Vesalius were intimate friends, so here between the artists and the anatomists there existed a helpful friendship to which the great Rembrandt has borne witness in his well known "Lesson in Anatomy." The Dutch anatomists are as famous for the minute beauty of their preparations as the Dutch painters for the perfect finish of their canvasses.

From the Netherlands great influence was exerted upon anatomical study in all the surrounding countries, especially in England, Scotland, France, and Germany.[9] Toward the end of the eighteenth century the chief advances in the science were being made in these countries. In Germany the liberal support given to the medical sciences in the universities during the nineteenth century led to an advance of anatomy equalled nowhere else.

The enormous development which anatomy has undergone since the time of Vesalius can be appreciated only by one well acquainted with the subject. Thousands of minds highly endowed have been eagerly devoted to its pursuit, and it has had its due share of men of genius to open up new and fruitful fields of work. A vast and complicated technique has been developed for furthering its growth. Numerous museums have been established for preserving specimens; beautiful and expensive laboratories have been built for its service. In Germany no university is too small or poor to deny it a specially designed and well constructed building.[10]

Several societies exist in different parts of the world for furthering its interests. Large libraries are devoted to the immense literature which deals with the special and general phases of the subject. Many periodicals[11] and new books each year are required to record its advance. Schwalbe's Jahresberichte for the year 1902 gives a list of nearly 4,000 articles dealing with vertebrate and general anatomy, by about 2,500 investigators.

DEVELOPMENT OF ANATOMY.

The anatomy of Vesalius was characterized by its clear, straightforward description of observed structure. His followers soon corrected the errors which he had made and carried their dissections into more and more remote parts of the body. In 1622 Aselli discovered the chyle vessels, in 1647 Pecquet the receptaculum of the chyle, and in 1651 Rubeck the lymphatics. Before many decades had passed most of the structures in the human body visible to the naked eye had been accurately described. Yet, even in this field of gross, descriptive human anatomy, new points of view are still from time to time brought forward and structures seen in new relations are truly seen for the first time.

Vesalius performed some experiments on animals to determine the functions of various organs. This led to further study of animal structure from the standpoint of comparative physiology. "From dissection of a living dog one can learn more in a day," said Colombo, "than in feeling pulses or studying Galen for many months." (Neuburger and Pagel, vol. II, p. 27.) Early in the seventeenth century Harvey discovered the circulation of the blood, and later in the same century Borelli worked out the mechanics of muscular movement. During the eighteenth century John Hunter in England, Haller in Germany, and Vicq d' Azyr in France advanced the study of comparative physiological anatomy and gave an impetus to the study of physiology which resulted, during the nineteenth, in its becoming an independent science.[12] The great discovery by the anatomist Bell, about a century ago, that the nerve fibres which serve to conduct nerve impulses into the central nervous system are other than those which serve to conduct impulses from the central organs to the muscles, was the first step in a definite study of localization of function in the nervous system. Since this discovery wonderful progress has been made in unravelling some of the mysteries of structure both of the central and the peripheral nervous systems.

Pathological anatomy, like physiology, has long since become an independent science. When bodies began to be frequently dissected it was discovered that many diseases are intimately bound

up with alterations in organic structure. The first to carry out an extensive study of diseased organs was Morgagni, (1682–1771).

Desire to penetrate deeper into structure than the unaided vision can go, led Eustachius, the great contemporary of Vesalius, to the use of simple lenses. But it was not until the further perfection of these and the invention of the compound microscope by Janssen and its improvement by Drebbel and Hooke, that microscopic anatomy began to make active progress. With the foundation of this the names of Hooke and Grew, of Leeuwenhoek, Malpighi and Swammerdam are imperishably associated. Malpighi was the first to extend the study systematically to animal tissues, Malpighi and Grew to that of plants. The blood capillaries and blood corpuscles were discovered and much new insight was gained concerning the true nature of glandular and other structures.

Meanwhile great advances were made in anatomical technique, among the most important of which may be mentioned the injection of blood vessels with melted wax by Swammerdam, which led to many discoveries concerning the distribution of these vessels; and the injection of fluids into the blood vessels, which made it possible to preserve anatomical material for slow, careful, minute dissection, necessary for exact study of structure.

At the end of the eighteenth century the next great step in advance was made by the brilliant French investigator, Bichat, who definitely formulated the conception of elementary tissues out of which, variously interwoven, all the organs of the body are composed and in the vital activities of which organic processes have their seat. Bichat disdained the use of the microscope, at that time an imperfect instrument, and invented various methods of distinguishing different tissues with the naked eye.

Bichat arrived, however, at but an imperfect conception of the tissues. The application of the improved compound microscope to the study of the tissues of growing plants and developing animals, led, after his death, to the discovery of new elements of structure in animal tissues and to a clearer conception of the nature of plant structure and finally to the formulation of the theory,

by Schleiden and Schwann, that the bodies of all organisms, both animals and plants, are composed of units of living matter, termed cells, and the products of the activities of these cells. Much study, especially in Germany, since 1840, has been directed toward the determination of the essential features of the cells and the tissues of animals and plants. The introduction of the cell doctrine into pathology and medicine by Virchow in 1855 has led to results of great practical value and has made the microscope indispensable to the physician. A complicated technique for preparing tissues from microscopic examination has been developed.

With the development of the microscopic study of the tissues and cells, the science of embryology has been closely associated. Aristotle, Galen, Fabricius (a pupil of Vesalius), Harvey, Malpighi, and other investigators, had studied the development of organisms prior to the eighteenth century, and during that century Haller, Bonnet, and others somewhat advanced the subject. Toward the end of the century some true insight was gained by Wolff into the nature of the early development of the hen's egg. Early in the nineteenth century this knowledge was much extended by von Baer and others. After the compound microscope came into extensive use, the ovum was found to be a single cell, fertilization was found to be due to the union of two cells representing respectively male and female elements. The complex structure of the higher organisms was found to arise from the cleavage of the fertilized ovum and the subsequent multiplication by division of the cells thus derived and their differentiation into various tissues.

A considerable share of the attention of productive anatomists for over half a century has been devoted to a study of the development of the general form and the differentiation of the organs and tissues of various organisms. The simpler conditions residing in the embryo have served to bring to light many essential facts of structure not easily to be made out amid the complex relations characteristic of the adult. W. His was a great leader in this field of study. (See F. Mall, American Journal of Anatomy, 1905.)

Of late years attention has been turned more and more to an experimental study of the conditions of organic development and

tissue differentiation. These studies have been conducted, on the one hand, largely by surgeons on man and the higher mammals in order to determine conditions of wound healing, tissue regeneration and the correlative dependence of part on part; on the other hand by anatomists and physiologists, zoologists and botanists, on plants, the lower animals, and on embryos, in order to gain insight into the laws of organic development.

While anatomy, during the past four centuries, has been developing in the interests of medicine and physiology along the various lines of descriptive anatomy, comparative physiological anatomy, histology, cytology, embryology, histogenesis, and experimental morphology, it has during the past century likewise received a great development from another standpoint.

The growing interest in animals and plants, which began about the time of Vesalius, led on the one hand to some study of the structure of the lower organisms and on the other to the discovery of so many different species that naturalists were forced to attempt systematic classification. It was eventually found that structure is the most satisfactory basis for the purpose. The study of anatomy from the standpoint of the similarities and differences in structures typical of various groups of organisms, has given rise to modern morphology. Cuvier extensively introduced the study of fossil forms and von Baer that of embryology into this field of study. It was discovered that a certain similarity exists between the successive stages of structural differentiation through which one of the more complex organisms passes during embryological development, the structure of organisms which paleontology has shown successively to have peopled the earth, and living organisms, arranged in a series, from the simplest to the most complex. Darwin's theory of evolution through natural selection led to a general belief in the genetic relationship of living things, those morphologically similar being most intimately related, and added new interest to this aspect of anatomical study.

The renewed impulse thus given to the study of structure and the simultaneous impulse given to the study of physiology by physics and chemistry, led not only to the formation of separate departments of physiology and anatomy, but also for a time to an unfortunate divorce between these two co-ordinate subjects.

Some morphologists went so far as to assert that anatomy in its physiological aspects should be left to the physiologist and that anatomists should concern themselves with the pure laws of structure. A large proportion of zoologists devoted themselves to a study of the comparative anatomy of dead animals and fossil forms and paid comparatively little attention to the relation of structure to function. But the development of experimental morphology on the one hand and the study of structural variation upon the other, has, during the past twenty years, led once more to the recognition of the value in biological investigation of keeping ever in mind the inseparable union of structure and function, form and environment.[13]

On human anatomy the morphological aspect of anatomy has had a marked influence by leading first to a study of the structures characteristic of different races of mankind, and then to a study of the variation in structure which different individuals show, and the nature and frequency of these variations.

Aside from the physiological and morphological points of view, human anatomy has been highly developed in its practical applications to medicine, surgery, and the fine arts.

ANATOMY IN AMERICA.

If now we turn to America we find until comparatively recently but few contributions to anatomy. In Europe as we have seen, the science arose in part from those interested primarily in the problems of medicine, in part from those devoted to the study of animals and plants. It is therefore of interest to trace the progress of anatomy in this country, first, in its relations to medicine, then to zoology and botany.

ANATOMY IN MEDICAL SCHOOLS.

The earliest medical schools founded in this country were established immediately before the Revolution by men who had been pupils of the great English anatomists, John and William Hunter in London, and of the Monros, at Edinburgh. A short course of didactic lectures and opportunity for dissection constituted the essential features of the curriculum. For a hundred years the

general standards of medical education rather declined than advanced. Dissecting served more to illustrate the text book studied for the sake of a quiz than to offer training in manual dexterity and in observation. The professors of anatomy were usually more engrossed in teaching authoratively and in the practice of medicine than in the advance of the science.[14]

Yet we owe a great debt to the men who in spite of popular ignorance and prejudice introduced and extended the study of human anatomy in this country. Thanks to the zeal of these men, often indeed amidst the greatest difficulties, practical anatomy was maintained in the better medical schools for a century before laboratories became a general part of our educational system. Thanks also to these early leaders state laws have been passed so framed as to furnish an adequate supply of material for this most fundamental of medical studies.[15]

Many of the teachers were men of character and force. A few, especially at the Philadelphia School of Anatomy and the University of Pennsylvania, were highly gifted men with scientific ideals.[16] But the prevailing traditions concerning anatomy and anatomical instruction, the placing of undue emphasis on didactic teaching and on memorizing, hindered their work. These traditions still serve to hinder the general progress of the subject in this country. (See F. P. Mall, Johns Hopkins Bulletin, Jan. 1905.)

Microscopic anatomy was long neglected in most institutions and then was generally introduced as an aid to pathology and not as an essential branch of anatomy.[17] Embryology is still inadequately treated in all but a very few institutions. The first good course in microscopic neurology given in a medical school in this country was that offered at the Johns Hopkins University in 1894.

On the whole American anatomy of the 19th century was essentially a diluted copy of the English anatomy of the 18th. Just as our earlier literary colleges were most of them modelled after the English colleges so our medical schools were more or less like the English schools. In spite of the friendship formed between France and the United States after the war of the Rebellion French influence never made itself seriously felt in our system of medical education. The works of Bichat were translated into

English and published in America early in the 19th century. Later, in the time of Louis, many Americans went to Paris for a medical education and some of them became distinguished physicians. Some slight stimulus to physiological experimentation was occasionally to be seen in America as a result of the great activity in France started by Magendie and Claude Bernard. But the English influence of the 18th century prevailed in American medical education until, in the latter half of the 19th century, men trained in Germany began to return to America filled with enthusiasm for the basal sciences.

Reform in medical education in America was inaugurated at Harvard in 1871 by President Eliot.[18] The entrance requirements were raised, the curriculum was lengthened and graded, the basal sciences (anatomy, histology and embryology, physiology, chemistry, and pathology, and more recently, bacteriology and pharmacology) were placed in the first half of the course, laboratories[19] were provided, and men scientifically trained were appointed to take charge of them.[20] Facilities for clinical instruction were likewise improved.

The reform thus inaugurated at Harvard led at first to a loss in the number of students and to a decrease in income, but soon the tide turned, public spirited citizens gave liberal sums of money to the school, and the better training there offered led to rapid growth. Other institutions have followed the example of Harvard and other university presidents have followed the lead of President Eliot, in demanding higher standards in medical education. The need of funds for laboratory courses and the desire for prestige, have led the faculties in charge of the medical schools to submit to some loss of control. Schools not connected with universities have followed so far as possible the lead of those thus connected, although often the improvements have been more apparent than real.

A most distinct advance in medical education in America was made when the Johns Hopkins University opened its medical department in 1893. Unusual opportunities were offered by the special endowment of the school; by its intimate connection on the one hand with a university which for fifteen years had supported advanced study and research in various sciences, including some

of those sciences most nearly related to medicine, and on the other, with a hospital richly endowed with special view to medical instruction; and by its faculty, selected from the country at large and solely from the standpoint of personal merit. Although in the better schools at that time merely a high school education was required for entrance, at the Johns Hopkins a degree was required from a college or scientific school in which a certain amount of biology, chemistry, and physics, French, German, and Latin had been studied, and, although in no school at that time were four years of medical study required, this standard was set up at the new school. But the chief service which the Johns Hopkins University has rendered to medicine in this country is the impulse which it has given to investigation and research in the medical sciences. Increased endowments and increased state support have enabled other institutions likewise to aid in this advance.[21]

Although the traditions hanging over anatomy have served in many ways to keep it from developing as rapidly as those basal sciences which have been more recently introduced into the American medical schools, still in the anatomical departments of some institutions notable advances have been made both in methods of instruction and in scientific activity.[22]

Important contributions to anatomy have also been made from the pathological and physiological laboratories of medical schools and by clinicians.[23]

BIOLOGICAL ASPECT OF ANATOMY.

Turning now to the biological aspect of anatomy in America we find that the study of the habits and distribution, and the features of color, form and structure characteristic of various species of animals and plants, living and extinct, began in this country early during the colonial days and has since had much support from individuals and from various States and the National Government.[24] Its chief monuments are to be found in the museums of the Philadelphia Academy, the Boston Society of Natural History, the New York State Museum, the Museum of Comparative Zoology at Cambridge, the Peabody Museum at Yale, the National Museum at Washington, the American Museum at New

York, the Field Columbian Museum at Chicago, the Carnegie Museum at Pittsburgh, and many other museums scattered throughout the country; and in the publications of these museums, of various learned societies, and of the State and National governments.

Productive study of the internal structure and of the physiology of plants and animals began in this country much later. Scholarly study of organic structure began with Jeffries Wyman,[25] and was extended by him and by Agassiz[26] at the Lawrence Scientific School established at Cambridge in 1847. Here good biological laboratory methods were utilized for the first time in America. For the last twenty years the anatomical laboratories at Cambridge have been in charge of E. L. Mark, whose great ability as an inspirer of investigation has lately been attested by a beautiful memorial volume of contributions from his pupils.[27]

Among the pupils of Agassiz who have contributed especially to the subject of animal structure may be mentioned A. Agassiz, W. K. Brooks, A. S. Packard, and B. G. Wilder.[28] The majority of Agassiz's pupils, however, have paid attention rather to systematic zoology than to comparative anatomy, although many have contributed papers dealing with comparative anatomy in its relations to systematic zoology.

At Yale,[29] Princeton,[30] the University of Pennsylvania,[31] the Johns Hopkins, and other institutions, departments of biology were established in the seventies. Of these the Johns Hopkins did the most to further the advance of biology because of the support which it gave to advanced and graduate work.[32] At this period also many Americans began to go to the German universities for the sake of biological study. Trained men thus became available for university and college positions and the teaching of biology has gradually passed from the hands of jacks-of-all-trades into those of specialists.[33]

In a number of universities the biological departments have been so extended in recent years as to embrace the subjects included in the first two years of the medical curriculum of the leading medical schools. This is of advantage because it gives breadth to biology as a science and depth to the training offered students preparing to study medicine.[34]

In addition to the facilities for anatomical study offered in the medical and biological departments of various universities, marine and lake laboratories,[35] museums, [36] and other institutions offer opportunities for research. The progress of anatomy in recent years in America has also been much furthered by the establishment of societies,[37] and journals,[38] devoted to it and kindred subjects.

AMERICAN CONTRIBUTORS.

The increasing interest in anatomy in America as well as the increased foreign interest in American anatomy may be judged from the fact that in Schwalbe's Jahresberichte for the years 1872–1881 I find the names of but 30 American contributors to anatomy; for 1882–1891, about 60; for 1892–1901, nearly 400; and for the one year, 1902, about 120 Americans.

There has been a general increase in the number of workers in all civilized countries but the increase has been unusually rapid in America. The general index of Schwalbe's Jahresberichte for the years 1872–1881 gives about 5,000 names of anatomists and physiologists. It may be estimated that at least 3,000 persons contributed papers on anatomy during this period. American workers thus constituted about one per cent. of the world's productive workers during that decade. For the decade 1882–1891 there are about 8,500 names in the general index of Schwalbe's Jahresberichte of which about 5,000 may be estimated as those of contributors to anatomy. For this period the sixty Americans contributors to the subject therefore constitute about 1.2 per cent. of the total number. For the decade 1892–1901 the names of about 10,000 persons are indexed. The 400 American contributors thus form about 4 per cent. of the total number. For the one year 1902 about 2,500 names are catalogued of which about 120 or nearly 5 per cent. were those of Americans.

While the figures mentioned are only approximate estimates based upon a single source of information, Schwalbe's Jahresberichte. they indicate a gratifying increasing interest in anatomy in this country. Yet when one considers the size of the country and the fact that probably $750,000 or more is spent each year in medical schools and biological departments on the

subject, it may readily be seen that in mere quantity we should do more than 5 per cent. of the world's work in this field. In quality I fear we could scarcely claim to do that much. A large number of the American contributors in the above table have written papers of small value on cases of abnormal development and similar topics.

From 1872 to 1881 the most productive American anatomists, judging from the space devoted to them in Schwalbe's Jahresberichte, were, E. D. Cope and O. C. Marsh in paleontology, A. Agassiz, H. Allen and J. Leidy in comparative anatomy, C. S. Minot in embryology, and T. Dwight in human anatomy. During the next decade, 1882–1891, the most productive men were G. Baur, E. D. Cope, O. C. Marsh, J. Leidy, and W. B. Scott in paleontology; H. Allen, H. Ayers, J. S. Kingsley, H. F. Osborn, and R. W. Shufeldt in comparative anatomy; H. Ayers, W. K. Brooks, S. H. Gage, F. Mall, C. S. Minot, J. A. Ryder, and C. O. Whitman in histology and embryology; H. H. Donaldson, E. C. Spitzka, M. A. Starr, and B. Wilder in neurology; F. Baker, J. D. Bryant, and T. Dwight in human anatomy. During the decade 1892–1901 E. D. Cope, J. Leidy, H. Allen, and J. A. Ryder were checked in the midst of scientific activity by death. The other workers of the preceding decade continued productive during this and in addition the names of several other active investigators appear:

In paleontology, B. Dean, C. R. Eastman, J. B. Hatcher, F. A. Lucas and H. F. Osborn; in comparative anatomy, E. P. Allis, C. H. Eigenmann, H. H. Field, O. P. Hay, W. S. Miller, and G. H. Parker; in histology and embryology, R. G. Harrison, G. C. Huber, J. B. MacCallum; in neurology, H. J. Berkeley, P. A. Fish, C. J. Herrick, A. Meyer, W. C. Spiller, and E. A. Spitzka; in human anatomy and physical anthropology, G. A. Dorsey, and A. Hrdlicka; and in invertebrate embryology and experimental morphology E. G. Conklin, C. B. Davenport, F. R. Lillie, J. Loeb, L. Loeb, T. H. Morgan, and E. B. Wilson.

AMERICAN CONTRIBUTIONS.

From this brief review of the development of the interest in anatomy, the facilities for its advancement, and of the names of

leading investigators we may turn to a consideration of the contributions made to the science in this country.

I shall not attempt, of course, to review all the contributions made to the science of organic structure by Americans. Thousands of papers have been published dealing with the form, structure and the development of various species of animals and plants, living and fossil, the value of which can be adequately judged only by specialists in different fields of zoology and botany. I shall try merely to call attention to some of the more recent work in fields that should be covered by a department of anatomy designed to play a part in medical education. These fields should be, I think, special human anatomy, in all its phases, from embrylogy to physical anthropology; the comparative anatomy of vertebrates, and more especially of mammals; neurology; histology; embryology; general morphology; and the technique of anatomical investigation and expression, including artistic anatomy.

I. Special human anatomy.[39]—Generations of gifted investigators, teachers and writers, in the three centuries and a half that have elapsed since the death of Vesalius, have so perfected the subject of descriptive systematic and topographical human anatomy that few sciences can boast of text-books and hand-books, atlasses and models so exact and satisfactory. There are still open, however, several fruitful fields of investigation in this branch, among which may be mentioned the statistical study of structural variation in relation to race, sex, age and social conditions, and certain fields of physiological and special topographical anatomy.

The value of statistical study of variation has long been recognized in physical anthropology and numerous studies have been made of variation in the relative proportion of length to width of the skull and similar simple external structural features, in order to determine racial and sexual characteristics. In America pioneer work in physical anthropology was done in the first half of the nineteenth century by S. G. Morton of Philadelphia, of whose collection of huamn skulls Agassiz wrote (Louis Agassiz, by E. C. Agassiz. 1885. p. 417): "Dr. Morton's unique collection of

human skulls is also to be found in Philadelphia. Imagine a series of six hundred skulls, mostly Indian, of all tribes who now inhabit or formerly inhabited America. Nothing like it exists elsewhere. This collection alone is worth a journey to America." Pioneer work was likewise done by Dr. D. A. Sargent who exhibited at the Chicago world's fair in 1893 a composite statue of the American college boy and one of the American college girl, each based on measurements of a large number of individuals. H. H. Wilder has recently contributed a most valuable paper on duplicate twins and double monsters in which he has shown that even the finger prints of duplicate twins are duplicated.

Recently attention has been turned toward variation in internal structure, and embryology and comparative anatomy have been called upon for their invaluable aid.

In this country valuable contributions to skeletal variation have been made by Boas, Dorsey, Dwight, Hrdlicka and others. For the layman, who has given up belief in a too literal interpretation of Eve's origin, it may not be uninteresting to learn that 2½ per cent. of people have only eleven ribs and 2½ per cent. have thirteen, as I have recently found from a statistical study, based upon my own observation and those of several other investigators. I have likewise been able to show by a statistical study of variation in the spinal column of embyros that variation there occurs with about the same frequency as in the adult.

Statistical studies have likewise been extended in this country to the blood vessels and peripheral nerves. Thus Walsch some years ago made an extended study of variations in the brachial nerve-plexus and more recently A. W. Elting and I have studied variation in the lumbo-sacral plexus in relation to side of body, age, sex and race. In this instance no very marked features were found to be characteristic of these different conditions but Bean has found that the branches of the subclavian artery in the infant differ from those of the adult.

Most statistical studies on internal structural variation have been confined to a given organic system, i. e. a part of the skeleton, a group of blood vessels or a set of peripheral nerves. In the studies on the lumbo-sacral plexus, mentioned above, we attempted a co-ordinate investigation of skeletal variation and found that

there is an agreement, though imperfect, between variation in the spinal nerves which supply the limb and variations in the spinal column with respect to the position of the limb-skeleton. These and subsequent studies have likewise shown that there are areas of the body in which structural variation is frequent and extensive and other areas in which it is less common and less in amount. Thus variation at the junction of the thoracic with the lumbar or lumbar with the sacral region of the spinal column is more marked than in the central area of the thoracic, lumbar or sacral regions, and variation in the distribution of the peripheral cutaneous nerves is especially prominent in the region of the junction of the limbs with the body wall.

A great value of this general line of work is that it may be carried on in the dissecting rooms and thus while the students are aided by a consequent quickening of their attention their arduous studies may to some degree be utilized for science.

Special study has been devoted to variation in the form of the brain in relation to the mental activity of the individual. Donaldson's study of the brain of the talented blind and deaf Laura Bridgeman was an important contribution. B. G. Wilder, at Cornell, has been an enthusiastic leader in the attempt to get brilliant individuals to bequeath their brains for special study after death and has accumulated quite a collection at Ithaca. Some of these brains he has already described at length. E. A. Spitzka is engaged upon an extended study of the comparative anatomy of the brains of individuals of various races and of various classes of society and has made most distinct advances in this line of work.

Some years ago a number of prominent scientists, William Pepper, Harrison Allen, J. Leidy, F. X. Dercum, and E. C. Spitzka, formed an association the object of which was to get the members to pledge their brains for subsequent anatomical study. E. D. Cope, A. J. Parker and Philip Leidy afterwards joined the society. At the death of six of these gentlemen their brains were deposited in the Wistar Institute at Philadelphia. For some time Dr. E. A. Spitzka, whose previous studies on the relation between variation in brain morphology and mental and social conditions has especially fitted him for the task, has been engaged upon a comparative study of these brains. He has discovered

that the corpus callosum, the chief fibre mass connecting the two halves of the cerebrum, is much better developed in individuals with a high mental capacity than in individuals of average ability. R. B. Dean, working in Professor Mall's laboratory, has discovered a distinct difference in shape between the brain of the negro and that of the Caucasian.

Real contributions to the teaching of human anatomy and to the care and preservation of material for the dissecting room have likewise been made by Americans. F. D. Weisse, professor of anatomy at the University of New York, published in 1886 a dissector's guide (Practical Human Anatomy) thoroughly original in design and of great value, but unfortunately not appreciated. At Columbia, G. H. Huntington has organized a splendid museum of comparative vertebrate anatomy as an aid to the study of human anatomy and has devised many useful methods for demonstrating special preparations to students engaged in dissection. Professor Huntington was the first to do away with didactic lectures to beginning students. At The Johns Hopkins University F. P. Mall has introduced the use of small dissecting rooms where two or three groups of students may dissect more quietly than in the old-fashioned large dissecting room, has devised several useful aids to dissection, has done away entirely with formal didactic lectures on descriptive anatomy and has encouraged the students to dissect carefully and thoroughly with book in hand. (See F. P. Mall, Anatomical Courses at the J. H. U. Bulletin of the Johns Hopkins Hospital, May–June, 1896.) The use of charts to serve as guides to the student in his drawing of dissected parts and for recording data gathered for scientific statistical study, and the use of clay modelling in the study of the bones and other parts of the body were also introduced in Professor Mall's laboratory, and a special study room has been developed where students may study at leisure frozen sections of the body, dissected parts and special preparations. These various aids to teaching have to a greater or less extend been introduced into other laboratories in America. Improvements in methods of instruction have been likewise inaugurated in several other laboratories.

The use of cold storage for the preservation of anatomical material is an American contribution. The first cold storage plant

to be used to preserve dissecting material was installed at Columbia University, New York. Similar plants have since been established in a large number of medical schools. While not necessary when but a small amount of material must be kept on hand, these plants are of value where a large amount of material must be stored. (See A. T. Kerr, The Johns Hopkins Bulletin XII, 1901. F. P. Mall, ibid., 1905.)

To the subject of physiological human anatomy comparatively few contributions have been made by Americans. Original work of great value, however, was done by Muybridge, who studied by means of photography the movements not only of some of the domestic animals but also of man and brought to light many new facts.

A number of American investigators have studied the distribution of the peripheral nerves in man from the standpoint of function. Important contributions to this subject have been made by M. Allen Starr, L. F. Barker, and Harvey Cushing.

Americans have made a considerable number of contributions to the topographical anatomy of special regions which are of surgical importance. In this connection should be mentioned the work of M. Broedel who has done so much to raise the standards of anatomical illustration in this country.

A department of anatomy undoubtedly should have a professor of artistic anatomy on the one hand to offer courses to artists seeking knowledge of organic structure, and on the other hand to train investigators in the technique of illustration.

The study of special human anatomy has been extended from the gross to the minute anatomy of the body. While knowledge of the specific nature of all of the human tissues is of special interest to pathologists and clinicians who desire to compare normal with diseased structures, the greatest interest in the field of special human microscopic anatomy and histology has been shown in the nervous system

H. C. Berkley and A. Meyer, among other Americans, have contributed to the knowledge of the structure of the central "psychical" nerve cells of man. F. R. Sabin's reconstruction of the medulla of the child is a widely known important contribution to brain anatomy. The work done by Ingebert in Professor

Donaldson's laboratory at Chicago in the determination of the number of nerve fibres in the spinal nerves of man and that of Helen Thompson in the determination of the number of nerve cells in the human cortex, likewise merit special mention.

Accurate descriptive anatomy of human embryos is of importance to human anatomy because the simpler conditions existing in the embryo tend to explain the essential amidst the complexity of adult anatomy. Thus Mall's studies of the development of the intestine have enabled him to point out a regularity in the position of the intestinal folds in the adult, a regularity not previously recognized. Professor Mall has at Baltimore probably the most complete existing collection of human embryos prepared for microscopic study. He has done much to introduce into this country the methods of reconstruction by means of wax plates developed by Born and His in Germany. In his laboratory plastic reconstruction of embryonic structures has been extended by Mall, Lewis, Streeter and Bardeen from the field of the central nervous system and viscera studied by Born, His, and others, to the peripheral nervous, muscular, and skeletal structures. Over sixty papers based upon his collection have been published.

Special mention should here be made of the pioneer work of Professor Mall in the study of pathological human embryos, a work of fundamental importance as a basis for a scientific teratology.

Having now briefly treated of some modern aspects of special human anatomy we may turn to a consideration of comparative organic anatomy.

II. Comparative organic anatomy.[40]—Primarily, we have seen, the study of comparative anatomy arose from those interested in physiological problems who turned to animals for knowledge not readily obtained from man. Later the desire to base the classification of animals and plants upon physical characteristics led to the development of ideas of type structure and of a pure science of morphology based directly upon comparative study of structure without regard to function. Of late the tendency is fortunately once more to study structures from their two-fold aspect of form and function. In the study of the organs we may compare

the gross general structure of a given organ as it appears in a series of animals or we may seek to determine the essential units of structure out of which an organ characteristic of many related animals is composed.

The majority of American biological investigators have, however, until recently been interested in structure rather from the standpoint of form characteristics of use in the systematic classification of animals than in the comparative anatomy of the organs as a basis of a rational comparative physiological anatomy. The skeleton and teeth, because of their value in systematic classification and in paleontology, have thus received the bulk of attention. L. Agassiz, G. Baur, E. D. Cope, J. Leidy, O. C. Marsh, H. F. Osborn, W. B. Scott, R. W. Shufeldt, and S. W. Williston are among those who have contributed most to this subject. E. D. Cope has been called by a leading American biologist, the foremost anatomist since Cuvier. J. K. Thatcher's theory of the comparative anatomy and development of the limbs is one of the most highly valued of American contributions to morphology.

There is a growing interest in the comparative anatomy of systems of organs other than the skeletal. Among the leaders in this study may be mentioned S. H. Gage, G. S. Huntington, J. S. Kingsley, J. P. MacMurrich, C. F. W. McClure, W. S. Miller and C. S. Minot. The work on the comparative anatomy of the nervous system I shall speak of later.

The comparative study of organic-units is of more recent development than that of the organs themselves. In some structures, like the voluntary muscles, the individual cells seem to be the only definite units of structure. In other organs the component tissue may be resolved into a vast number of more or less distinct units, each of which in turn is composed of cells arranged with definite relations to vascular and other structures. Many glands, like the liver and pancreas, may readily be seen to be thus made up, while in other organs, like the spleen, it is more different to recognize the units of structure. F. P. Mall has been a leader in the investigation of these structural units. J. L. Flint has done much to extend the knowledge of their supporting framework. G. C. Huber has added most materially to the knowledge of the structure of the kidney and other glands. Warthin has discov-

ered that the lymph nodes may be resolved into two classes with intermediary forms, the true lymph glands, and the hemolymph glands. One of the most important contributions yet made in this field is that of Professor Miller, who was the first definitely to determine the true nature of the organ units of the lung.

III. Histology.[41]—The study of the tissues is closely associated with that of organology. To this subject Americans have made several important contributions. Of these perhaps the most important is the discovery by F. P. Mall of a new kind of fibrous supporting tissue which he called reticulum. The discovery of an element of this kind in anatomy is equivalent to the discovery of a new chemical element in chemistry. Previously only two kinds of fibrous connective tissue were recognized, the white non-elastic, and the yellow elastic. Recently by a process of differential staining Mallory has added a fourth to this group. Kyes, Flint, and Mall have done much to extend our knowledge of reticulum as the supporting framework of many glands. R. R. Bensley has done beautiful work in the study of the nature of the epithelium of the alimentary canal; Chittenden, Eycleshymer, Gage, Huber, and others have added to the knowledge of muscle, Minot and Mall to that of the blood vessels. Although in 1876 Packard could write that up till then no attention had been paid in biological monographs to histology, today the work done in America certainly compares favorably with that done in Europe.

An important part in histology is played by methods of technique used in preparing tissues for microscopic examination. Minot has contributed largely to this by the development of microtomes for cutting thin sections, and Delafield, Van Giesen, and Mallory by the invention of several important methods of staining. Mallory introduced the use of carbon dioxide as a means of freezing tissues for sectioning and Cullen the use of formaline for hardening frozen sections so that they may be stained.

R. R. Bensley and L. F. Barker have discovered useful microchemical methods for the determination of iron in the tissues. F. P. Mall has developed extensively the use of artificial digestion as a method of tissue differentiation.

IV. Cytology.[42]—The importance of an understanding of the physical nature of the living units of organic structure has led to a special study of the cell. It is here that botanists and zoologists find themselves upon a common ground, because in the most essential features animal and vegetable cells are similar in structure. A great number of American investigators have contributed to the subject. Processor E. B. Wilson has written a text-book on "The Cell" that stands perhaps at the head of the books that have been written on that subject. The chief cytological studies have been carried out on the sex cells and on nerve cells, and hence we may pass on to a consideration of embryology and neurology.

V. Embryology.[43]—Embryology has attracted a great number of modern American investigators. The contributions to the subject concern the formation of the sexual cells, the spermatozoa and the ova, the conjugation of these cells and the early stages of structural differentiation, the formation of the various organs of the embryo, and the accompanying development of the complex tissues of the adult from the simple tissues of the embryo.

It would be absurd here to try to enter into a description of the vast amount of work that has been done by Americans along these lines. The work done here compares favorably with that done in any other country. The first to develop active interest in modern methods of the study of vertebrate embryology in this country were C. S. Minot, J. Ryder, and C. O. Whitman. Minot has contributed one of the most important text-books on vertebrate embryology yet written, and has established at the Harvard Medical School the most complete existing collection of vertebrate embryos prepared for microscopic study. This collection has already served as the basis of many important contributions, and is likely to prove of the greatest value for many years to come. Among those who have charge of laboratories where the greatest amount of research in comparative embryology is being done may be mentioned C. O. Whitman and F. R. Lillie, Chicago; E. G. Conklin, Pennsylvania; G. C. Huber, Michigan; S. H. Gage, Cornell; F. P. Mall, Johns Hopkins; E. L. Mark and C. S. Minot, Harvard; J. S. Kingsley, Tufts; T. H. Morgan and E. B. Wilson, Columbia.

Of the more fundamental American work in the field of comparative vertebrate embryology mention may be made of that of Minot and Lee on the foetal membranes, of Minot and his pupils on the blood vessels, especially of his formulation of the conception of sinusoids, or vascular spaces which arise from the ingrowth of glandular tissues into blood vessels during embryonic development, of F. R. Sabin's work on the development of the lymphatics from the veins, of MacCallum's on the arrangement of the musculature of the heart, of Huber on the development of various glands, of Mall on the histogenesis of the connective tissues and of various organs, of Harrison on the histogenesis of the peripheral nerves, of MacCallum and Eycleshymer on the histogenesis of muscle and of W. S. Miller on the lungs.

VI. Neurology.[41]—The predominating importance of the nervous system in the animal economy has led to so much special work on the gross and minute comparative anatomy and the physiology of the nervous system as to give rise to a special branch of science called neurology. In addition to the special study of the human nervous system, comparative studies on the gross and minute anatomy of the peripheral and central nervous systems and organs of special sense have been made by many Americans. Without attempting here to summarize these various contributions or their value, I shall merely call attetnion to some of the more important work of Americans. In L. F. Barker's "The Nervous System," (1899), full justice is done American workers.

H. D. Schmidt and A. J. Lanterman discovered the segments in the medullary sheath of the nerve fibre which are known by their names. E. A. Birge some twenty years ago pointed out the correspondence in number between the motor cells in a given segment of the spinal cord and the medullary fibres of the corresponding nerve root. In H. H. Donaldson's laboratory at Chicago statistical methods of determining the relations of nerve fibres to nerve cells and to various peripheral structures have brought to light many important facts. In this laboratory likewise valuable work is being done in the determination of the effects of starvation and similar factors on the development of the nervous system. In fishes and amphibia O. S. Strong, C. J.

Herrick, and J. B. Johnston have determined the morphological distribution in the cranial nerves of various component sets of nerve fibres each of which has specific functions to perform. H. C. Berkley was the first to apply successfully the Golgi method of impregnation to the study of nerve endings in the viscera; C. F. Hodge, once a member of the biological staff here, was the first to study the effect of fatigue on the nucleus of the nerve cell; G. C. Huber, one of the first to apply the newer methods of staining to nerve endings in muscle, and P. Sargent has opened up several interesting lines of work. Loeb's monograph on the physiology of the nervous system contains original theories concerning structure as well as function. Howell and Huber have contributed important papers on the regeneration of nerves. Mallory, Huber, Ingebert, and others have made additions to our knowledge of neuroglia. And so I might continue; but the list of American contributions to comparative neurology is too long for it to be possible to do justice to all in this discussion.

VII. Experimental morphology.[45]—Along with the descriptive study of embryological development there has grown up, largely within the past twenty years, a field of study of even more fascinating interest, the experimental study of the factors which determine form and tissue differentiation. In the study of the healing of wounds, surgeons have for ages had occasion to test the formative power of various parts of the human body. For over a century, biologists have been acquainted with the wonderful restorative powers possessed by certain of the lower organisms. But it was not until Pflüger and Roux, early in the eighties, published their experiments on the developing ovum of the frog, that the attention of zoologists was turned to the great value of accurate experimental study of the formative potentiality of organic structures. In the development of this field of work Americans have played a foremost part. Among them may be mentioned E. G. Conklin, C. B. Davenport, R. G. Harrison, F. R. Lillie, W. H. Lewis, J. Loeb, T. H. Morgan, and E. B. Wilson.

I can here merely mention a few of the directions which these experimental studies have taken.

First there has been an attempt to determine to what extent

formative potentialities are localized in the ovum, and it has been shown that while in some organisms definite areas of the ovum are capable of developing approximately merely the structures which would arise from them in normal development, small parts of the ova of other organisms are capable of giving rise to symmetrically perfect embryos. Thus a quarter of the ovum of a sea urchin, which under normal circumstances would give rise to a definite area of the body, may, if isolated under proper conditions, give rise to a complete larva one-fourth the normal adult size. Wilson, Morgan, Conklin, and Lillie have been among the leaders in this field of work. (See E. B. Wilson, Science, Feb. 24, 1905.)

Another line of study has been that of the regenerative capacity of the lower organisms and the internal and external factors concerned. Morgan has been a leader in the field and his monograph is a standard work. F. R. Lillie, F. Peebles, C. M. Child, H. W. Rand, and C. Zeleny, among others, have contributed extensively to the subject.

J. Loeb, who though a German by birth, is by adoption an American and in both inventiveness and intensity of application a truer American than many of his fellow workers, may be counted the most original biological investigator in America. Among the important contributions which he has made to experimental morphology may be mentioned his work on heteromorphosis or the phenomena which some organisms show of regenerating in place of lost parts new parts unlike those lost, a head in place of a tail for instance, and his well known discovery of artificial parthenogenesis brought about by altering the physical or chemical nature of the media surrounding unfertilized ova.

The effects of heat and light on development have been studied by Davenport, Loeb, Tower, Edwards, Greeley, and others; the effects of the Roentgen rays in checking development in ova and regeneration in organisms by Gilman, Baetjer, and Bardeen; and on the skin and other tissues of the higher organisms by Pusey and Caldwell and others.

Tadpoles have been much utilized for the experimental determination of the power of correlative differentiation in the embryo and of organs to develop in unusual situations. R. G. Har-

rison has shown that the sense organs of the lateral line and the musculature may develop independently of nerves; W. H. Lewis that if the rudiment of the optic vessicle be placed in some other region than the head it may stimulate the differentiation of a crystalin lens from the epithelium of that region. F. R. Lillie and F. Peebles have made important experiments on the effects of mutilation of parts in the developing chick. R. G. Harrison, W. H. Lewis, and T. H. Morgan have made interesting studies on the grafting of a part of the body of a tadpole of one species to that of another species.

In the higher organisms, such as the mammals, conditions of development preclude extensive mechanical experimentation on the developing embryo. After birth, although the powers of regeneration of complex organs like the arms or legs or head, characteristic of some invertebrates, is no longer found, there is a high capacity of regeneration of peripheral nerves, of blood vessels and of most of the tissues of the body. In many respects the best work that has yet been done on nerve regeneration is that of Howell and Huber. F. P. Mall has performed some fundamental experiments on the regeneration and regulation of the tissues of the intestine after section. L. Loeb has executed some important experiments on tissue transplantation. American surgeons have made numerous contributions to the subject of wound healing. But I have not at present time to enter further into details concerning this important line of work.

The effect of physiological activity on the structure of cells was inaugurated by C. F. Hodge's experiments on the effects of fatigue on nerve cells. P. K. Gilman has shown a similar effect on the nuclei of muscle cells.

VIII. Teratology. Experimental morphology is essentially experimental pathology since it is impossible to experiment on the living substance without subjecting it to abnormal conditions. In the great laboratory which nature conducts very abnormal forms, monstrosities, are not infrequently produced. The study of these organisms that have failed to develop in a normal manner, often throws light on the factors at play in normal development. The study of teratology is therefore quite as important to the student of normal as to the student of pathological anatomy.

We have many descriptions of isolated instances of malformation of animals in this country although no American until recently has handled the subject in a broad spirit. H. H. Wilder is at present making most valuable studies of double monsters.

IX. Variation and heredity.[46]—Lastly I wish to touch briefly upon a field of biological investigation which in many aspects lies within the province of the anatomist. In speaking of human anatomy I showed that a most important line of work is the study of structural variation in races and individuals. It is well known that certain structural peculiarities like six fingers, or functionless ears* tend to run in families. Statistical studies of inheritance of characteristic structures and functions, first carried out on a large scale by Galton, have been extended from man to the lower animals and plants, and have thrown much new light on organic development. One of the foremost investigators in this field is C. B. Davenport, who, through his own work and that which he has inspired in others, has brought large and fertile areas under cultivaton. The experimental study of inheritance through carefully controlled breeding experiments has likewise received notable contributions from American investigators, among the foremost of whom stand C. O. Whitman, C. B. Davenport, and W. E. Castle. The effects of hybridization on the germ cells have been followed by M. P. Guyer, W. H. Moenkhaus, and W. S. Sutton.

My time is growing short. I have but imperfectly sketched various fields of work, from simple descriptive human anatomy to experimental studies of inheritance, which properly come within the province of anatomy and toward the cultivation of which an anatomical laboratory run on a broad scale should contribute. Anatomy like all the other sciences is simultaneously advanced by workers in many countries. In singling out some of the contributions made here I have merely wished to show that American workers constitute an important factor in the present progress of the science.

In this progress, work done in the laboratories at this univer-

*The work of Alex. G. Bell on the inheritance of deafness is one of the best statistical biological studies that has ever appeared.

sity has constituted a distinct element. We hope to see the part played by Wisconsin a yet greater one; the laboratories and facilities of the new department become a center of attraction for those desirous of doing advanced work in anatomy; museums and a library developed that may be looked to with confidence by anyone desirous of the most accurate information concerning organic structure; courses of instruction maintained capable of developing the power of accurate observation, deep insight and broad grasp. In these aims we are sure of a stimulating union with the other scientific departments of the university.

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1, (p. 87). BIOLOGY AT WISCONSIN.

The development of the study of the biological sciences at the University of Wisconsin is indicative of the general progress in this field during the past thirty years in this country. Prior to 1875 didactic lectures had been given in 'natural history," and for a time in physiology and hygiene, and in comparative anatomy and entomology. In 1875 E. A. Birge became instructor in zoology and offered laboratory work. In 1877 a "Science Hall" was built at a cost of $80,000. In this building the various sciences were accommodated and laboratory instruction was offered in zoology and botany. These two departments grew rapidly. In 1881 courses in histology and embryology were begun. In 1884 the overcrowded "Science Hall" burned and in 1887 the present "Science Hall" together with special buildings for chemistry, a heating plant, and machine shops, were finished at a total cost of $345,000. In the new building zoology and botany were given much better quarters and better equipment than of old, an excellent course preparatory to the study of medicine was established, and opportunity for advanced work and research was offered. Since 1892, W. S. Miller has done much to develop vertebrate anatomy. Bacteriology, at first given by Professor Birge, became in 1893 a separate department under the charge of Professor Russell.

The rapid growth of the scientific, as well as of the other departments of the university, soon caused the new Science Hall to be over-crowded. Some relief was felt when in 1901 the College of Engineering, which up to this time had been housed in Science Hall, was provided with a special building. In 1902–3 the spacious attic of Science Hall was remodelled in such a way as to provide quarters for a botanical green house and for an attractive set of laboratories for human anatomy, and in 1904 a department of anatomy was established. The building is much over-crowded, however, and soon provision must be made for housing elsewhere one or more of the six departments, physics, geology, botany, zoology, anatomy and psychology, now quartered in it, as well as for the department of physiology soon to be established.

Thirty years ago one man, R. H. Brown, was the only instructor in natural history. Twenty years ago Professor E. A. Birge was the only instructor in zoology, and Professor W. Trelease, the only instructor in botany. Ten years ago there were two instructors in addition to

Professor Birge in the zoological department, Professor Barnes and L. S. Cheney were instructors in the botanical department, and H. L. Russell had charge of bacteriology. Today the following men are on the staffs of the biological departments of the university.

Zoology: Professor E. A. Birge, Assistant Professor W. S. Marshall, G. Wagner, C. T. Vorhies.

Anatomy: Professor C. R. Bardeen, Associate Professor W. S. Miller, Dr. B. M. Allen, Dr. F. Schmitter.

Botany: Professor R. A. Harper, Assistant Professor C. E. Allen, R. H. Denniston, W. G. Marquette, E. W. Olive, J. B. Overton, G. M. Reed, and Miss H. Sherman.

Bacteriology: Professor H. L. Russell, Assistant Professor W. D. Frost, E. G. Hastings.

In addition there are a number of other biologists connected with the school of agriculture.

2, (p. 87). DEFINITIONS OF ANATOMY.

"Anatomy, or the science of the structure of organized bodies." Owen, Anatomy of Vertebrates, London, 1866, Vol. I, p. 6.

"Anatomy, a science the province of which is to determine the construction, the form and the structure of organized bodies, i. e. of bodies which either are or have been living." W. Turner, Encyclopaedia Brittanica, IX Edition.

"Anatomy is and remains the science of the structural parts of the organism and of the laws of their origin and transformation whether these structural parts are visible to the naked eye or only through the microscope." A. von Koelliker, Die Aufgaben der Anatomische Institute, Würzburg, 1884, p. 5.

3, (p. 88). UTIMATE NATURE OF LIVING SUBSTANCE.

"Our surest knowledge is confined in the main to structural relations, the form of the tissue elements with which the phenomena of consciousness are bound up, their mutual relations, their localizations in the brain. To trace the phenomena back to basal substances and forces is not possible; we know merely that the chemical substances present in the brain come into play; we surmise that these elements are united in the living brain into the most complicated bodies of our planet but at present we know only products of decomposition of the psychical substances; and thus the determinable boundaries of this

field of natural knowledge still lie in foggy distance." Flechsig, Gehirn und Seele, 1896, p. 11.

"What a living being is and what life is can scarcely be truly formulated in a short definition, only this may be said, that life rests in a special characteristic organization of matter and that with this organization furthermore special processes or functions are bound up such as are never found in lifeless nature." Hertwig, Die Entwicklung der Biologie im 19. Jahrhundert, Jena, 1900, p. 4.

"Undoubtedly these general considerations have their value in connection with problems with which we are dealing only in the thorough investigation of the components which serve to distinguish biological objects from chemical objects. We sum up this distinction ordinarily in the word *life*. If we inquire into the parts of this concept which may be recognized and measured we find the following to be true: Living beings in the first place are not stable, but on the contrary are stationary structures. Rapid changes take place in them of such a nature that gain and loss counterbalance one another so that the whole system experiences only slow changes (which are almost all periodic). Since all physical changes may be represented as displacements of different kinds of energy in space and time living organisms are characterized by the fact that they keep their condition of energy approximately constant in its nature and amount, while a constant current of various energies flows through their bodies. According to the general laws of energy this can take place only in such a way that the living organism takes up energy of a higher potential and gives it off at a lower potential. In the meantime the energy has been used for those transformations which make up the various activities of life, namely, movements, the production of heat, reproduction, etc." (Otswald, W.: The Relations of Biology and the Neighboring Sciences, Univ. of Cal. Pubs., Physiology, Vol. I, No. 4, p. 24.)

"Living organisms are chemical machines, made up essentially of colloidal material, which possess the peculiarity of developing, preserving and reproducing themselves automatically." (J. Loeb, "Recent Development of Biology," Address, Congress of Arts and Science, St Louis, Science, Dec. 9, 1904.)

4, (p. 89). GREEK ANATOMY.

For details concerning the ancient Greek anatomy reference may be made to Neuburger and Pagal's "Handbuch der Geschichte der Medicin," Jena, 1902; Carus', "Geschichte der Zoologie," and to the numer-

ous other books which have been written on the history of zoology and medicine.

5, (p. 89). SALERNUM.

Vid. F. Merkel, Verhandlung der Anatomische Gesellschaft, IX, Basal, 1895.

One of the first steps in the revival of learning in Christian Europe was the growth of a great medical school at Salernum during the eleventh century and its definite organization in the twelfth. This school represents in a way the first of the modern universities. Roger II, in 1137, instituted the first state examinations in medicine. Even to practice surgery, which for many centuries after this was in most countries in the hands of barbers, a year's attendance at lectures on anatomy and surgery was required. At Salernum the medical student took a preliminary training of three years in logic and language, studied medicine and surgery for five years, then passed an examination and placed himself under some physician for practical training. Those acquainted with medical education will recognize at Salernum in the Europe of the dark ages, nearly a thousand years ago, a higher general standard than is found in many parts of the United States today. (See S. S. Laurie, Rise of the Universities.)

The school at Salernum represented a survival of what scientific medicine had managed to pass through the vicissitudes of Italy from the third to the twelfth centuries, although its history can by no means be clearly traced back of the tenth century. The earliest existing records show it to have been a civil, not a monastic institution. Jews were active in its management. Practical anatomy was conducted on the pig, which was deemed at that time most nearly of the lower animals to resemble man in internal structure. An anatomy of the pig was written there. During the twelfth century medicine was re-introduced from Moorish Spain into Christian Europe. The school at Salernum was greatly influenced by this movement and ultimately was crowded out by the establishment of rival schools at Montpellier, Naples, Bologna and other universities. But the pig remained the classical object for anatomical demonstration for over two centuries. Today it is once more assuming a position of dignity as a favorite object for research and instruction in mammalian embryology.

6, (p. 90). ANATOMY IN ITALY PREVIOUS TO VESALIUS.

During the fourteenth and fifteenth centuries help was gained from the painters and sculptors of the period, who were eager to learn the

nature of human structure from dissection and whose influence with the Church and State led to a powerful support from popes and princes which otherwise anatomy might not have enjoyed. Under Paul III (1534–49) a school for anatomy and botany was erected in Rome and a living for the prosector was guaranteed. Another source of aid came from the literary revival of this period and from the art of printing which did so much to make possible a comparison of texts. In the fourteenth century there are said to have been but nine books at Paris; in the fifteenth, eight hundred were published. The Arabic anatomies were compared with the original Greek, and Aristotle and Galen came into great favor. But the critical faculties developed by the study of texts led more and more to a study of nature, when the texts failed to agree, and thus to new knowledge. (Vid. Neuburger and Pagel, Handbuch der Geschichte der Medicine, Bd. II, Einleitung, where these ideas are developed at greater length.)

In the study of historical periods from the standpoint of an environment to the development of which thousands of great men have contributed earnest lives of self-devotion, it is difficult to prevent a feeling of personal superiority over those who lived before this development took place. And thus we of today are apt to smile at the childishness of men who for centuries taught imperfect ape and pig anatomy as that of man, whose ideas of the relation of structure to function have long since been outgrown, and who were wont, when descriptions read in their text-books failed to agree with structure seen, to apologize for the structure and deem book statement true. As for instance when it was pointed out to Sylvius that the human sternum is composed of three parts while Galen described it as composed of seven, Sylvius said that doubtless in the good old days of Galen when men were heroes the sternum was composed of seven bones but for modern degenerate man three sufficed. (Vid. Merkel, Anatomische Gesellschaft, 1895.) But like the human skeleton, human nature has remained much the same during at least all historical periods. Even today we find text-books called "human histology," "human embryology," and "human physiology," illustrated largely from lower animals, not always for the sake of comparison, but with the mistaken idea that such illustrations serve well enough to describe human structure and function; and much modern biological speculation is little better than the fumosities that escaped through Mondinus's skull. Here in America during the last half century Gray became such an authority on gross human anatomy that to many the two terms have seemed synonymous and thousands of students, lacking confidence in their power to see for themselves, have turned away from apparent imperfections

actually found in human structure to get what they are sure must be the real truth from Gray.

7, (p. 90). VESALIUS.

Roth's biography of Andreas Vesalius, 1892, gives a most interesting account of Vesalius and of his influence. Of the predecessors of Vesalius, Leonardo da Vinci seems to have been the first to make accurate anatomical illustrations and some historians consider him the true founder of modern human anatomy. See Jackschath, "Die Begrundung der modernen Anatomie durch Leonardo da Vinci, etc." Verhandlung der Gesellschaft deutscher Naturforscher und Aerzte, Karlsbach, 1902. A. Forster in "Einiges über die Beziehungen Vesal's zu Leonardo da Vinci und zu Marc Antonio della Torre," Archiv. f. Anatomie und Physologie, 1904, p. 197, discusses this paper and defends the reputation of Vesalius.

8, (p. 91). ANATOMY IN ENGLAND.

A special interest attaches to the development of schools of anatomy in England and Scotland because these schools have formed the chief model for courses in anatomy offered in this country. Dr. W. W. Keen in an address delivered before the Philadelphia School of Anatomy, a school closely modeled after the leading London school of a similar nature, gives the following account of the early development of practical anatomy in England. (A Sketch of the Early History of Practical Anatomy, Philadelphia, 1874, pp. 12–15.)

"England was among the first to profit by the shining example [of Italy]. Soon after the founding of the College of Surgeons in 1540, through the influence of Dr. Caius, the king's physician, and the founder of Caius College, Cambridge, Henry VIII granted to the College of Surgeons the privilege of dissecting four felons annually, and in 1564 Elizabeth gave the same privilege to the College of Physicians. In 1581 the latter college created the lectureship on anatomy, and in 1583 built in Knight Rider Street the first anatomical theatre. Here, in 1615, Harvey was elected lecturer, or, as it was then called, reader, in anatomy, and here he gave his first public demonstrations of the circulation of the blood about a year later.

"The facilities for general dissection, however, were very limited, and, as if to discourage it still further, in 1745 a fine of £10 was imposed on any one dissecting outside of the Barber-Surgeons' Hall. But such

a state of affairs could not long exist. The profession, under the lead of William Hunter, soon broke away from such bonds, and for over half a century almost every distinguished anatomist had dissecting rooms attached to his private dwelling, where he and his pupils cultivated the science. In 1770 William Hunter bought a lot in Great Windmill Street, London, opposite the Haymarket, and built on it a dwelling-house, an antomical theatre, dissecting rooms, and a museum. The lecture-room was lighted from above, and the seats rose as in our own amphitheatres. Here he lectured, assisted by his brother John, by Hewson, and by Cruikshank, till his death, in 1783. Here he collected his splendid museum, now in Glasgow, at a cost of £100,000, and his brother John began his own collection, which cost him before its completion £70,000, and now forms the chief ornament of the Museum of the Royal College of Surgeons. At William Hunter's death the anatomical school passed into the hands of his nephew, Baillie, and then successively to Cruikshank, Wilson, Sir Benjamin Brodie, Sir Charles Bell, and Shaw, and finally to Mayo and Caesar Hawkins. On Mayo's removal, in 1833, to University College Hospital, this celebrated school came to an end. But it had left its mark. Thousands of educated anatomists had gone forth from its walls to practice all over Great Britain and in this country. It furnished William Hunter's museum to Glasgow in 1807, John Hunter's to the Royal College of Surgeons, London, and, later still, those of Wilson and Sir Charles Bell went to ornament the museum of the College of Surgeons of Edinburgh, and that of Mayo to University College, London. From it as a foster-mother, too, along with the institution of new public schools connected with the hospitals, many other private schools sprang up, and presented the finest opportunity for the diffusion of anatomical knowledge, so that in 1825–6, besides the hospitals, there were no less than seven such private schools of anatomy in London. . . .

"I have already quoted the Edinburgh act of 1505, which allowed of the annual dissection of a criminal, and also the early experience of the first Monro, which shows how rarely this was made available. The first Scotch anatomical theatre was built, and the first public demonstrations given, in 1697. But it was not till 1720 that a regular professor was appointed. At that date Monro primus was elected professor, at the extraordinary salary of £15 per annum! From this time till 1859, when Monro the third died, the history of Edinburgh anatomy and that of this astonishing family, are almost identical. True, John Bell and Knox, Charles Bell, Barclay, Innes, and others, lectured in private schools; but the Monros held the sceptre. All of them lived to old age, Alexander primus dying at seventy, Alexander

secundus at eighty-four, and Alexander tertius at eighty-six. All were professors early in life; at twenty-three, twenty-one, and twenty-five respectively. All of them taught for long periods: thirty-eight, fifty-four, and forty-eight years; and father, son, and grandson, they held the anatomical chair in Edinburgh from 1720 till 1846, a period of one hundred and twenty-six years!"

9, (p. 91). ENTRANCE OF ANATOMY INTO RUSSIA.

Into the western countries of Europe anatomy was extended as a natural result of awakened popular intellectual interests. Into Russia it was forced by the arbitrary will of Peter the Great. Sunk in superstitious barbarism, the Russian people are said during the seventeenth century to have had the greatest horror of dissection. The Dutch physician Bremburg went to Russia in 1626 and carried with him a skeleton for study. When this was learned he was almost lynched by the people and had to leave the country. (von Töpley, Neuburger and Pagel, Handbuch der Geschichte der Medicine, 1902, Vol. 2, p. 317.) In 1697 Peter made his memorable journey to Holland. Here he studied the microscope under the great naturalist Leeuwenhoek, and human anatomy under Ruysch, whose beautiful cabinet of anatomical preparations he afterward bought. The collection is in part still to be seen in the Academy of Science at St. Petersburg. Many of the specimens are said to have been ruined in their trip from Holland to Russia because the Russians who had them in charge drank up the alcohol in which they were preserved. Peter founded a military hospital at Moscow and a medico-surgical school at St. Petersburg, and, acting under the advice of the great German philosopher, Leibnitz, left the plans for the establishment of the Academy of Science where anatomy has since been cultivated by some of the greatest of its students.

10, (p. 91). ANATOMY IN GERMANY.

The following table shows the number of professors, instructors and servants, and the amount of yearly appropriation for the anatomical and physiological institutes, the number of students in anatomical courses, and the yearly appropriation for laboratories and museums of other departments in the German universities during the year 1892–3. Since that date there has been a general increase, but not of the remarkable nature which is to be seen today in the American universities. From 1891 to 1899, for instance, the number of "ordentliche"

DEPARTMENTS IN GERMAN UNIVERSITIES, 1892–3.

Universities.	Anatomical Institutes.								Physiological Institutes						Appropriations for Other Institutes.						
	Professors.	Assistant professors.	Docents.	Prosectors.	Assistants.	Servants.	Number of students.	Appropriations (Marks).	Professors.	Assistant professors.	Docents.	Instructors.	Servants.	Appropriations (Marks).	Pathology.	Pharmacology and physiol. chem.	Hygiene.	Zoology (including museums).	Botany (including garden).	Physics.	Chemistry.
Berlin I	1	1	3	2	3	2	500	40,540	1	3	....	7	5	46,396	24,450	17,202	21,280	87,110	105,625	28,650	24,090
Berlin II	1	1	....	2	2	1		11,430									18,630	20,560	31,550	3,000	17,435
Bonn	1	2	....	2	4	2	125	16,310	1	1	1	3	2	12,635	10,160	6,250	.....	18,206	22,595	7,675	25,740
Breslau	1	1	....	1	2	2	170	16,358	1	1	1	3	2	11,059	13,312	5,800	4,500	9,156	29,994	7,552	13,564
Erlangen	2	1	....	1	1	1	95	6,831	1	....	1	1	2	8,410	6,510	.....	.....	6,237	14,355	6,511	17,157
Freiburg	1	1	2	2	....	2	135	6,000	1	....	1	1	2	2,000	3,600	540	1,500	2,500	3,974	2,900	9,600
Giessen	1	....	1	1	....	1	45	6,857	1	....	....	1	1	4,080	7,870	2,430	4,570	6,500	4,880	4,220	13,000
Göttingen	1	1	1	1	1	1	105	14,180	1	1	....	1	1	6,855	8,080	5,100	5,400	9,800	24,890	9,010	30,810
Greifswald	1	1	1	1	1	1	160	13,571	1	....	....	1	2	6,170	6,800	3,950	.....	6,432	12,441	7,310	12,603
Halle	1	.	1	1	2	2	100	15,319	1	.. .	....	1	1	5,444	7,924	3,140	4,440	9,449	18,603	8,835	14,033
Heidelberg	1	1	2	1	1	2	.....	6,700	1	...		2	1	6,000	3,600	2,200	1,500	2,400	11,000	2,200	14,000
Jena	2	1	....	1	1	1	95	11,400	1	....	1	1	1	4,900	3,600	.... .	2,000	3,500	8,000	4,500	....
Kiel	1	....	....	1	1	1	80	10,100	1	....	...	1	1	6,850	7,500	3,200	4,550	7,400	13,650	5,980	14,600
Königsberg	1	1	...	1	2	2	100	16,172	1	....	....	1	1	5,780	8,120	5,910	4,450	10,048	15,030	10,550	14,350
Leipzig	1	2	1	1	3	4	325	16,200	1	..	...	4	3	10,030	7,230	6,710	5,000	5,593	20,713	6,000	26,650
Marburg	1	1	1	1	2	1	155	13,356	1	...	....	3	4	12,989	9,692	4,982	4,242	6,400	17,808	8,450	15,209
Munich I	2	....	..	2	2	3	200	21,529	1	....	....	2	2	6,969	15,681	5,325	37,084	.....	13,350	8,965	17,987
Munich II	1	....	....	1	....	....		3,900													
Rostock	1	...		1	....	1	40	7,100	1	..	....	....	2	3,450	5,850	4,100	2,350	6,100	7,245	3,950	7,400
Strassburg	2	1	1	1	3	3	95	17,788	1	1	....	2	2	7,575	12,088	9,125	.....	5,975	14,775	13,080	26,250
Tübingen	1	1	....	2	....	1	100	19,772	1	..	...	1	1	4,535	9,333	6,399	.....	8,230	19,040	.....	11,740
Würzburg I	1	1	1	1	2	3	300	21,190	1	...	....	2	1	10,882	11,386	3,300	3,210	8,147	13,183	8,224	21,007
Würzburg II	....	....	....	1	1	....	.....	3,831													

professors in the medical faculties increased from 211 to 224, and the number of students from 27,057 to 32,834. At Breslau, the yearly appropriation for the anatomical laboratory for 1893 was 16,358 M. In 1903 it was 25,478 M. But such an increase is unusual.

This table is based primarily on data given in W. Lexis, "Die deutsche Universitäten," 1893. See also Minerva and W. Lexis, "Die deutsche Universitäten," 1904.

11, (p. 91). ANATOMICAL PERIODICALS.

Waldeyer in Merkel-Bonnet's Ergebnisse for 1902 reviews 178 periodicals devoted in part or wholly to anatomy.

12, (p. 92). PHYSIOLOGY.

H. Boruttau in Neuburger and Pagel's Geschichte der Medicin, Bd., II., p. 455, gives the following dates of the establishment of separate physiological institutes in the German universities:

Breslau 1811	Marburg 1848
Königsberg 1849	Tübingin 1853
Kiel 1855	Heidelberg 1857
Berlin 1858	Bonn 1859
Jena 1860	Göttingen 1861
München 1863	Leipzig 1865
Rostock 1865	Würzburg 1865
Freiburg 1867	Halle 1870
Erlangen 1872	Greifswald 1872
Strassburg 1872	Giessen 1891

13, (p. 96). ANATOMY AND PHYSIOLOGY.

Thus Hertwig ("Die anatomische Unterricht," Jena, 1881, p. 23) says:

"With all this one should not lose sight of the fact that since physiology has become independent the real purpose and the immensely wide and still rich field of work for anatomists is morphology. In this lies the center of gravity of their activity, which while extended out to be sure to wider fields at the same time must not be quite misplaced at the cost of morphology in the direction of physiology."

Yet both in this article and elsewhere Hertwig recognized that "every division of a science into special fields, as for instance of

biology into anatomy and physiology, is an artificial one and one not to be strictly carried through. Structure and function of a part hang together in innermost union and can in truth be understood only while united.

"As unfounded as vitalism is the mechanical dogma, that life with all its complicated phenomena is nothing else than a chemico-physical problem." (Hertwig, "Biologie im 19 Jahrhundert," Jena, 1900.)

If teleological anatomy were to be avoided by physiologists because physics and chemistry are limited in their application to it, and by anatomists because it is not a pure study of structure, a fertile field of study would be neglected. As a matter of fact the highly developed and important subject of the movements effected by the voluntary musburgh, and that of Mayo to University College, London. From it as cular system is neglected in most of the text-books on physiology used by American students and is most inadequately treated in the modern popular text-books of anatomy.

14, (p. 97). MEDICAL SCHOOLS IN AMERICA PREVIOUS TO THE PRESENT REFORM.

A private course in human anatomy was offered at New York by Doctors John Bard and Peter Middleton as early as 1750, and one by Thomas Cadwallader at Philadelphia at about the same time. In 1752–55 a series of public lectures on human and comparative anatomy and the history of anatomy was given at Newport, R. I., by Dr. William Hunter, a relative of the famous English anatomists, John and William Hunter. In 1762 Dr. W. Shippen advertised in the *Pennsylvania Gazette* as follows: "Dr. Shippen's anatomical lectures will begin tomorrow evening at six o'clock at his father's house in Fourth St. Tickets for the course are to be had of the Doctor at 5 pistoles each, and any gentlemen who incline to see the subject prepared for the lectures and learn the art of dissecting, injection, etc., are to pay 5 pistoles more." In 1765 Dr. Shippen and Dr. John Morgan, both of whom had been favorite pupils of the Hunters in London and had later graduated at Edinburgh, organized a school of medicine as a department of the Pennsylvania College, afterwards the University of Pennsylvania. Similar institutions were organized by active young physicians and established in connection with various literary colleges, among them one at Kings, afterwards Columbia College, New York, in 1768; Harvard College, Cambridge, 1783; Dartmouth College, New Hampshire, 1797; University of Maryland, Baltimore, 1807; Yale College, New Haven, 1810; Brown University, Providence, R. I., 1811; Transylvania Univer-

sity, Lexington, Ky., 1817; Bowdoin College, Portland, Me., 1820, and the University of Virginia in 1822.

In 1807 the Regents of the University of New York fathered the establishment of a College of Physicians and Surgeons at New York City, and in 1813 of one at Fairfield, N. Y. In 1823, under the charter of Williams College, the Berkshire Medical Institute was established at Pittsfield, Mass. In 1813 the medical department of Columbia University was discontinued and the faculty passed over to the College of Physicians and Surgeons.

In the *Harvard catalogue of 1846–7* an interesting account is given of the foundation of the Harvard school. It is quoted here in part as an example of the method of establishment of these early schools: "Before the Revolution no medical school existed in Boston, nor in the State of Massachusetts. No examinations and no licenses to practice were established, nor any other means by which the public could be assured of the qualifications of a medical practitioner. There were no dissections, and even examinations of the bodies of deceased persons were rarely permitted. The means of instruction were limited to the information that could be obtained from the private practice of the physician, and to reading the very few books which he might have in his library. Now and then a favored individual went home to England, as it was said, to walk the hospitals of London, and to attend lectures at the great institution at Edinboro'. Some time before the Revolution, in 1765, a medical school was established in Philadelphia, and afterwards, in 1768, one in New York; but the modes of traveling were so imperfect that these cities were considered almost inaccessible from this part of the country.

"The Revolutionary War supplied abundant opportunities of cultivating practical medicine and surgery, and the murmurs of prejudice against anatomy were not heeded amidst the bustle of the camp and the cries of the wounded. Under such circumstances were found many good physicians and surgeons, among whom was Dr. John Warren, of Boston.

"This gentleman was a surgeon in the army from the battle of Bunker Hill to the end of the campaign in the Jersies. Being then compelled by illness to quit the army, he settled in Boston, was there appointed Military Hospital Surgeon, and improved the opportunity this situation afforded for cultivating the study of anatomy to an extent till then unknown in this place. In 1781 he began a course of lectures on Anatomy, which was attended by physicians in practice, and by a few medical students. These lectures attracted so much attention, that the

Government of Harvard University invited Dr. Warren to lecture at Cambridge, and give his aid in the formation of a medical school.

"This school was established, and went into operation in 1783. Dr. Warren was Professor of Anatomy and Surgery, Dr. Aaron Dexter of Chemistry and Materia Medica, and Dr. Benjamin Waterhouse of the Theory and Practice of Medicine. The lectures of these gentlemen were attended by medical students from different parts of New England, usually in number about twenty, and also by those members of the Senior Class of the University who obtained the consent of their parents. The opportunities for dissection were generally limited to one subject in the course, and the efforts required to carry this subject through the course, at the time when Boston did not communicate with Cambridge by any bridge, were very great. The lectures were generally from two to three hours long but were attended steadily, and listened to closely. The degree of Bachelor of Medicine was first conferred in 1785, and, according to the system then followed, after the lapse of seven years that of Doctor of Medicine.

"Medical instruction continued in this condition until the year 1809. At this time a public dissecting room was opened at No. 49 Marlboro' street by Dr. John C. Warren, son of the Professor of Anatomy, who had been appointed Adjunct Professor three years before, viz.: in 1806. The demonstrations and dissections given at that period were attended by most of the younger physicians of the town, and by some medical students. In 1809 Dr. John Gorham was chosen Adjunct Professor of Chemistry.

"As Cambridge did not afford any opportunities for seeing medical and surgical practice, the number of students there did not materially increase, and it was proposed, and finally arranged, that the medical institution should be transferred to Boston. This arrangement was effected on the condition that certain Professors should give lectures to one or more classes at Cambridge. A course on Human and Comparative Anatomy has accordingly been given annually in the spring by the Professor of Anatomy, and a course of Hygiene by the Professor of Medicine."

The *early schools* were established primarily on the plan of the English and Scotch medical schools and were designed to offer short terms of didactic lectures, practical anatomy and clinical instruction to students whose main education was gained through apprenticeship in a physician's office. The Hunters had offered facilities for dissection to their students and this example was followed in the first schools in this country and in all those subsequently established. In this respect the

American schools were for some time in advance of many of the continental institutions.

Thus His in his address at Basel in 1885 (Gedenkschrift zur Eröffenung des Vesalianum) showed that in the university in that city, where once the great Vesalius taught, practical human anatomy really began with the professorship of Jung in 1823.

Welch has pointed out (Biology and Medicine, University Record, Chicago, July, 1897, Vol. II, p. 142) that human anatomy was the only subject anywhere taught by the laboratory method until the end of the first quarter of the present century. In 1824 Purkinje established a physiological laboratory in Breslau and in 1825 Liebig one in chemistry at Giessen. The Hunters seem to have been the first to offer students free facilities for dissection. As a rule previously anatomy had been taught by demonstration.

Early in the nineteenth century the medical schools in America began to multiply rapidly in number. From 1776 to 1810 there were seven schools started; from 1810 to 1840, twenty-six; from 1840 to 1875, forty-seven. Of these eighty schools sixteen had been discontinued by 1876.

The best accounts of the medical schools up to 1876 are those by N. S. Davis, entitled, "Contributions to the History of Medical Education and Medical Institutions in the United States of America, 1776–1876." (Special Reprint U. S. Bureau of Education, 1877), and by J. M. Toner, "Contributions to the Annals of Medical Progress in the United States before and during the War of Independence." (U. S. Bureau of Education, 1874.)

Standards of medical education fell as schools multiplied. Schools connected with the literary institutions dissolved their connection either wholly or in part, and that decline set in which for the better part of a century was so often deplored by the idealists in the medical profession.

In most schools only two decades ago the entrance requirements were merely nominal and a diploma was granted to anyone who would pass a nominal year of apprenticeship with a physician and listen three months for two successive years to a hodge-podge of lectures on the medical sciences and medical practice.

Some other facilities than those of the short lecture term were, however, offered in the better schools, especially in the large cities. The student could attend clinics, practice dissecting, and often had the privilege of listening to a second set of lectures if he wished. For these various privileges extra fees were usually, though not always, charged. The fees for the regular lecture courses varied from $75.00

to $140.00 in the leading schools. Previous to the establishment of laboratories the expenses, except for cadavers, were small, and large incomes were derived by the proprietor-professors of many of these schools.

The medical schools of the country were thus described by the Commissioner of Education in 1870:

"The medical colleges of the country are mostly joint stock corporations which furnish as little medical education as they can sell at the highest rate they can obtain. Their number is excessive and the competition between them very keen. They are consequently disinclined to introduce any new features which may scare away students of low acquirements or which may add seriously to the expenses of the institution." (U. S. Bur. Ed. Rep., 1870, p. 395.)

In 1892 a committee of French specialists made a study of medical education in the United States. From their report (U. S. Bureau of Education, Report, 1892–3, pp. 601–613) the following remarks may be quoted:

"Young physicians who wish the title of professor route out the statutes (for a medical school), elect a council of administration, and request the state authorities to inscribe the new creation in official registers. This is seldom refused and is equal to a regular authorization. The prospectuses are freely issued in order to announce the new creation; the medical papers publish the courses and the list of the professors who but yesterday were but simple physicians, more or less unknown. This is busness; it must be hurried, and here, as everybody knows, the Americans are at home. Students come in greater or less numbers and in the second year diplomas are distributed. The graduates are then permitted to practice medicine in the State where the school is established."

"At first the resources of the school are limited, as the fees of the students and the sum given by the founders are the only sources of revenue. The buildings are rudimentary, and the laboratories poorly and meagrely equipped. But if by chance some distinguished and energetic person has come into the corporation, reputation does not wait for the lapse of years and endowments increase. Splendid iron and brick buildings are erected, dispensaries and soon hospitals are founded."

"The medical career is a profession like any other and the epithet 'liberal' would not be understood in a country where only one thing is desired, namely, to gain with the greatest rapidity the greatest possible amount of money; where the effort is only to perfect oneself in his art

in order to get still richer. Therefore, of course, no one thinks of erecting high barriers at the entrance to the schools.

"The professional courses which the student must follow bear a close analogy to those which the professors of our provincial schools have to give. The lectures even at Philadelphia and New York hardly bear comparison with those in the faculties of Bordeaux and Nancy. In America there is nothing to be compared with the faculties of Lyons and especially those of Paris. The theoretical courses are generally good but elementary; the exercises in dissection are as a rule rudimentary. The practical work, except in chemistry, leaves much to be desired. On the contrary this is not the same with dental schools, the triumph of the United States."

In some instances "sun down" and "night" schools have been and still are maintained in order to make doctors out of working men by giving them didactic lectures evenings after the day's work is finished. (See Dexter, "History of Education in the United States," 1903. Reference is here made to some of the literature bearing upon the subject of medical education in the United States.)

Of the nominal three years of medical study which were required the following description gives a good picture of the first:

"The student remains in the medical man's office for a period varying from three months to a year, during which, if his preceptor is a busy man and popular practitioner, he has not been examined on the progress he is making enough to make it worth mentioning or remembering. He during this time reads some work on human anatomy without any appliances except a defective set of bones, the relics of his preceptor's dissecting days, and perhaps a fair set of anatomical plates; he also reads some books on physiology, materia medica, and perhaps chemistry, and even attacks the theory and practice of medicine; sometimes, moreover, surgery is also read. During all this route he is apt to be bothered by the strange and seemingly barbarous phraseology of these works and to wonder why the language he is accustomed to speak cannot describe the facts his eyes see," etc. (U. S. Bur. Ed. Rep., 1870, p. 395.)

After some such course of learning the student for two successive years attended lectures at a medical school.

The following account of the *mode of teaching* by one of the brightest teachers at one of the best of the schools previous to the present reform indicates well that what the conditions in medical schools in this country were until a comparatively short time ago.

"Dr. Cheever writes:

'It nears one o'clock, and the close work in the demonstrator's room in the old Medical School in North Grove Street becomes even more hurried and eager as the lecture hour in Anatomy approaches. Four hours of busy dissection have unveiled a portion of the human frame, insensate and stark, on the demonstrating-table. Muscles, nerves, and blood-vessels unfold themselves in unvarying harmony, if seeming disorder, and the "subject" is nearly ready to illustrate the lecture. . . The room is thick with tobacco smoke. The winter light, snowy and dull, enters through one tall window, bare of curtain, and falls upon a lead floor. The surroundings are singularly barren of ornament or beauty, and there is naught to inspire the intellect or the imagination, except the marvellous mechanism of the poor dead body, which lies dissected before us, like some complex and delicate machinery whose uses we seek to know.

'To such a scene enters the poet, the writer, the wit, Oliver Wendell Holmes. Few readers of his prose or poetry could dream of him as here, in this charnel-house, in the presence of death. The very long, steep, and single flight of stairs leading up from the street below resounds with a double and labored tread, the door opens, and a small, gentle, smiling man appears, supported by the janitor, who often has been called on to help him up the stairs. Entering, and giving a breathless greeting, he sinks upon a stool and strives to recover his asthmatic breath. . .

'Anon recovering, he brightens up, and asks, "What have you for me to-day?" and plunges, knife in hand, into the "depths of his subject,"—a joke he might have uttered. Time flies, and a boisterous crowd of turbulent Bob Sawyers pours through the hall to his lecture-room, and begins a rhythmical stamping, one, two, three, and a shout, and pounding on his lecture-room doors. A rush takes place; some collapse, some are thrown headlong, and three hundred raw students precipitate themselves into a bare and comfortless amphitheatre. Meanwhile the professor has been running about, now as nimble as a cat, selecting plates, rummaging the dusty museum for specimens, arranging microscopes, and displaying bones. The subject is carried in on a board; no automatic appliances, no wheels with pneumatic tires, no elevators, no dumb-waiters in those days. The *cadaver* is decorously disposed on a revolving table in the small arena, and is always covered, at first, from curious eyes, by a clean white sheet. Respect for poor humanity and admiration for God's divinest work is the first lesson and the uppermost in the poet-lecturer's mind. He enters, and is greeted with a mighty shout and stamp of applause. Then silence, and there begins

a charming hour of description, analysis, simile, anecdote, harmless pun, which clothes the dry bones with poetic imagery, enlivens a hard and fatiguing day with humor, and brightens to the tired listener the details of a difficult though interesting study. We say tired listeners because—will it be believed?—the student is now listening to his *fifth* consecutive lecture that day, beginning at nine o'clock and ending at two; no pause, no rest, no recovery for the dazed senses, which have tried to absorb Materia Medica, Chemistry, Practice, Obstetrics, and Anatomy, all in one morning, by five learned professors. One o'clock was assigned to Dr. Holmes because he alone could hold his exhausted audience's attention.'" (Morse, J. T., Life and Letters of Oliver Wendell Holmes, vol. I, pp. 174–176.)

Of course few students were privileged to listen to so entertaining a talker as O. W. Holmes but the description here given offers a fair picture of one of the three chief parts of the old fashioned course in anatomy, the didactic lecture illustrated by demonstrations on a dissected body. Practical dissection formed another part of the course. The bodies were often limited in number and poorly preserved. The dissecting rooms were usually large rooms in the attic of the medical building. Dissecting was done mainly at night in the midst of a noisy disorderly crowd of smoking and expectorating youths mentally weary from the day's lectures and full of animal spirits seeking outlet. The general conditions of disorder may be best realized from the fact that it was considered a great luxury and the mark of an advanced and up-to-date school if the dissecting room was furnished with a cement floor that might from time to time be flushed with a hose.

It is needless to say that there was little opportunity for that quiet so necessary for scientific insight. In large part the teaching of anatomy was left to practicing surgeons who came to look upon it as an appendage to their trade. The professor of anatomy, usually a man engrossed in the practice of medicine, gave didactic lectures on the subject while the demonstrators of anatomy, who overlooked the work in the dissecting room, were young men waiting for patients and looking forward to being surgeons. To most of them it seemed that enough anatomy for practical surgery was to be found in the text-books and that the ideal was to learn them by heart. Few seemed to realize that a surgeon usually has text-books at hand, so that memorizing more than a few essentials is as unnecessary as learning the directory of a city by heart when one moves to a new town. But teachers who have no burning interest to deepen their own understanding of the subject they profess always tend to encourage routine memorizing of authoritative data. And thus medical students were led to devote the major

part of their time to text-books in preparation for quizzes rather than to training their powers of observation and manual dexterity in the dissecting room. From quiz-masters one can expect few real contributions to science and few were made.

The third part of the work in anatomy consisted of the quizzes in preparation for the examinations in anatomy. This portion of the work assumed an increasing importance soon after several of the States instituted examinations for licenses to practice. The examinations within the school then naturally were made more severe because no school liked the reputation of having many of its graduates fail to pass the State examinations. Frequently the quizzes formed a part of the instruction offered by the school but in a great many instances private quizzes were given by some of the teachers in the school, by some of the older students or by persons not officially connected with the school. Often considerable incomes were derived by the quiz-masters.

While I have described the above methods of teaching anatomy in the past tense it is not to be assumed that they have been entirely superceeded by more rational methods. In a comparatively few schools have the recent waves of reform managed to sweep entirely away the rubbish of the past.

15, (p. 97). SUPPLY AND CARE OF ANATOMICAL MATERIAL.

For the early schools in this country bodies were obtained only with difficulty and, as in England, professional body-snatchers had to be employed previous to the enactment of State laws which give to the medical colleges the bodies of those dying without friends. The house of Dr. Shippen of Philadelphia was attacked in 1765 by a mob the members of which were excited by the report that the church burying-ground had been despoiled to furnish material for his private class in anatomy, an accusation which he denied. (W. W. Keen, Sketch of the Early History of Anatomy, p. 15.) In New York soon after the close of the war of the Rebellion a mob excited by the report of stolen bodies broke into the dissecting room at Columbia College and precipitated a riot which lasted for two or three days. Often great difficulties were encountered. Early in the thirties Dr. Beck is said to have carried bodies in a buggy all the way from Boston to Albany in order to supply material to his classes in the latter city. Even up to very recent years scandals connected with the supply of anatomical material have occurred from time to time.

In 1830 Massachusetts passed a law giving the bodies of paupers dying in State charge and in 1833 one giving those of county paupers unclaimed by friends to the recognized medical institutions of the State. "But these acts," says W. W. Keen (Early History of Anatomy), "were only obtained after the community had been driven to it, not only by the repeated outrages to the public peace and public feelings, but also by repeated crimes." Other States passed similar laws. The Pennsylvania law, passed in 1868, although at first rendered difficult of operation by popular prejudice, paved the way for the law of 1883 which has served as a model for many similar laws. Dr. Keen in a recent letter to the writer says concerning the law: "May I call your attention to one point in particular? The anatomy law of Pennsylvania, so far as I know, is the best law of its kind in this country. *It gives us more material for dissection than we know what to do with.* Not only are medical schools, but individuals, county societies and colleges which have a biological course, supplied with bodies freely. All of the details can be given you, if you desire them, by Dr. Addinell Hewson, 1115 Spruce St., Philadelphia, the Secretary of the Board. It is a very curious fact that the gentleman who drew up the law, my colleague, Professor William S. Forbes, of the Jefferson (Medical School), was its first and only victim! By the very timely death of his father-in-law, the hearing of his case was postponed, interest in it finally died out, and in some way (I do not remember just how) he escaped any trouble."

In the Proceedings of the Association of American Anatomists, 1896 (Science, III, 1896), may be found the report of a special committee of the Association which investigated the laws relative to anatomical material in this and several foreign countries. In this report an abstract of the Pennsylvania law is given and the law is highly commended. In essence the law reads that all unclaimed bodies of persons dying in public charge shall be turned over to an anatomical board for distribution for scientific purposes. Today in many States ample legal provision is made for legitimate needs. Still we find the professor of anatomy at the University of Texas complaining as late as 1902 that he has to purchase bodies obtained in an irregular manner because the State laws are inadequate to furnish the State University with material. (See President's Report, University of Texas, 1902.)

The professor of anatomy of another medical school connected with a State University has recently informed the writer that those in charge of the state and county public institutions, which furnish unclaimed bodies for scientific study, demand from ten to twenty dolars for each body and even then the supply is so limited that he is forced to turn

to irregular channels for an adequate supply of material. Although state laws strictly forbid traffic in bodies there is a firm in one of the Southern states that furnishes bodies to institutions situated in several of the Northern states, and other firms supply more limited territories.

In a recent article (Anatomical Material, Its Collection and Its Preservation at the Johns Hopkins Anatomical Laboratory, the Johns Hopkins Bulletin, vol. 16, 1905) Professor F. P. Mall gives an interesting account of his experiences when the Johns Hopkins Medical School was established in 1893. At that time but forty-nine bodies came through regular channels to supply the twelve hundred students in the various medical schools of Baltimore and the new school but increased the demand on the inadequate supply. For a time recourse had to be made to irregular sources of supply. The organization of a strong Anatomical Board, composed of members elected from the faculties of the several schools and the enlistment of the services of the Commissioner of Health of Baltimore has since served to offset the inadequacies of the present State laws in Maryland and to furnish all schools with a fairly adequate supply of material.

In the report of the Committee of the Association of American Anatomists, referred to above, an account is also given of the methods utilized for preserving bodies in this country. The limited supply furnished, until comparatively recently, necessitated that the bodies be embalmed instead of being dissected fresh. This latter method is still the practice in many parts of Europe.

Of recent years material is more plentiful but it is still felt in the leading schools that it is better for a student to dissect a small amount of material carefully and thoroughly rather than a large amount of material rapidly and superficially. Methods of preservation are therefore of importance. Many methods have been used. For a description of these see the Report of the Committee mentioned above. The best preserved bodies for purposes of dissection which I have seen in the dissecting rooms of this country are those injected with a mixture of alcohol, carbolic acid and glycerine. Where a large number of bodies are preserved cold-storage is of great advantage.

The use of cold-storage for the preservation of bodies intended for dissection was introduced by Professor Huntington at Columbia University in 1893 and soon afterwards at the Johns Hopkins University by Professor Mall. In the recent paper referred to above Professor Mall comes to the conclusion that while cold-storage is of advantage in many ways it is by no means essential. He recommends vats in which bodies may be immersed in 3% carbolic acid. In several institu-

tions the cold-storage plants have been discontinued and the bodies injected with the carbolic acid mixture and wrapped are found to keep well in an alcohol saturated atmosphere.

In addition to the report of the Committee of the Association of American Anatomists, see F. P. Mall, "Anatomical Courses at the Johns Hopkins University," Bulletin of the Johns Hopkins Hospital, May-June, 1896; and "Preservation of Anatomical Material," idem, Feb., 1905; A. T. Kerr, the Johns Hopkins Bulletin, VII, 1901.

16, (p. 97). ANATOMY IN THE BETTER OF THE OLDER SCHOOLS.

At the time of the foundation of the earliest medical schools in this country the foremost institutions for the practical study of human anatomy were the Windmill Street School of the Hunters in London and the Edinburgh School under the Monros (see note 8). The best of the early teachers of human anatomy in this country were trained in these schools and brought with them to this country high ideals of the value of practical dissection and of comparative vertebrate anatomy.

At the *Medical Department of the University of Pennsylvania* Dr. John Morgan, one of the founders, was a pupil of the Hunters. His publication on "The Art of Making Anatomical Preparations" led to his election to membership in the Royal Society of London. Dr. William Shippen, a friend and fellow-student of Morgan's, was professor of anatomy, surgery and midwifery at the medical school for forty-three years.

From 1808 to 1818 Casper Wistar was professor of anatomy. Thomas Jefferson wrote to Wistar in 1807, "I have a grandson, the son of Mr. Randolph, now about fifteen years of age in whose education I take a lively interest . . . there are particular branches of science which are not so advantageously taught anywhere else in the United States, as in Philadelphia in your Medical School for anatomy, etc." (See Benjamin Franklin and the University of Pennsylvania, F. H. Thorpe, U. S. Bur. of Ed., Circul. of Information, 1892, No. 2.)

From 1819 to 1831 Dr. Philip S. Physick was professor of anatomy, from 1831 to 1853 W. Horner, and from 1853 to 1891, J. Leidy.

Wistar wrote a good text-book on human anatomy and made a contribution to the structure of the ethmoid bone; W. E. Horner wrote a text-book on "Special Anatomy and Histology," and a "United States Dissector," discovered the tensor tarsi muscle (London Med. Repository, 1822), and among other papers contributed one on the "Odorifer-

ous Glands of the Negro." (Am. Jourl. of Med. Sc., Vol. XXI, p. 13.) Wistar founded and Horner did much to develop the fine collection of anatomical specimens now beautifully housed in the Wistar Museum, erected in 1892 through the generosity of General Wistar. J. Leidy, one of the best known of American scientific investigators, a man whose interests ranged over wide fields, contributed chiefly to the subjects of helminthology and vertebrate paleontology. He was a beloved teacher of human anatomy and wrote a text-book on the subject. (See T. G. Lee, Proceedings American Academy of Science, XXVII, pp. 437–442.) Since the death of Leidy, G. A. Piersol has been professor of anatomy.

The stimulus given to medical education by Morgan, Shippen and other Philadelphians who had received inspiration from the teachings of the Hunters made Philadelphia the foremost center of medical education in this country for nearly a century. Following the English example numerous private schools for teaching anatomy and other subjects were established by the leading physicians of the city and in 1825 the *Jefferson Medical College* was established and long rivalled the Medical School of the University in popularity. In 1832 G. S. Pattison, "formerly professor of anatomy in the University of Maryland and lately professor of anatomy and surgery in the University of London," was made professor of anatomy. The following quotation from the catalogue of the University for 1832 will show the ideals held by one of the leading teachers of the day.

"The value of the extensive Museum as an appendage to a school of Medicine, is too self-evident to require argument. To the Professor, as a source for obtaining objects for the illustration of his lectures, it is invaluable, and to the Student it is no less so. It is to him a field to which he can constantly refer for a solution of his doubts and difficulties. Visiting the Museum, and assisted by the explanations of his Professor, subjects which may have appeared to him during the lectures full of difficulty, are rendered simple and intelligible. In the present advanced state of Anatomical Science, how is it possible for the Professor to teach, or the Student to understand its minutiae, without the aid of preparations? How can the Professor of Materia Medica instruct his pupils, without exhibiting to them, in all their states, the difficulties of the Materia Medica? The eye is a most important organ in the acquisition of knowledge, and whenever the teacher can bring it into operation, he should not fail to do so. Having at his command an extensive collection of Preparations, his lessons can be forcibly fixed on the memories of his pupils by ocular demonstration.

"Abroad, a Museum is considered as absolutely essential to every system of Medical tuition; and the magnificent collections of the Hunt-

ers, and the Monros, &c., in Great Britain, and of Sömmering, Meckel, Rudolphi, and Cuvier, &c. on the Continent of Europe, prove the value which these Masters attached to preparations as instruments of instruction in Medical Science. Unfortunately, in our own country, sufficient attention has not heretofore been given to forming extensive collections of preparations. The arrangements of our Medical Institutions are, in many respects excellent, and the distinguished men which they have educated have conferred the highest honor on their Professors. But, although we feel proud in the admission of this fact, we are constrained to acknowledge that no school in our country has as yet collected such a Museum as to be sufficient for the illustration of the lectures of the Professors. Indeed, our best collections are inferior to those possessed by the most paltry private School in Europe. It is the determination of the Professors of Jefferson Medical College, that this *desideratum* shall no longer be allowed to exist in their Institution. Rich as the United States is in all the subjects of the Vegetable, Mineral, and Animal Kingdoms, and liberally supplied as Philadelphia, in particular, is, with Dead Bodies, there is no reason why they may not in a very few years, have open for the examination and instruction of their pupils, a splendid and extensive collection of the various subjects of their lectures.

"The present Museum belonging to Jefferson Medical College, as compared with the other collections attached to similar institutions in this country, is a respectable one. It will serve as a nucleus for the formation of a magnificent Museum, and the Professors trust they will have the co-operation of the Profession, and of their Students, in the accomplishment of this desirable object.

"It is customary in many of the Medical Institutions of Europe, for the Students attached to them to prepare, during the course of their studies, an Anatomical Preparation, and to leave it in the College Museum, as a memorial of their connection with their Alma Mater, The Professors hope that this example will be followed by the young gentlemen who may in the future be educated in Jefferson Medical College. The name and date being inscribed on the specimen, it serves to perpetuate the connection which has existed between the Students and their Professors, and in years afterwards, when they shall have become distinguished members of the Profession, should they, or their children, visit the Halls of their former studies, the preparations they have made will recall to the former delightful recollections, and will afford to the latter a powerful incentive to exertion. The Son would feel unworthy not to emulate, and, if possible, excell the Father in his devotion to his studies.

"Another and an important advantage, will be gained by the Student leaving as a gift a Preparation to the Institution where he has been educated. To make a handsome Anatomical Preparation, very considerable labour is required, and it is a kind of labour the most valuable to the surgeon. It gives him dexterity in the use of the scalpel, a dexterity without which no man can ever become able and distinguished as an operator.

"*Practical Anatomy* is, of all the departments of his studies, the one from which the Student of Medicine will derive most benefit during the term of his Collegiate Studies. Every other branch may be studied, and studied with advantage, after he has graduated. Indeed, all the Professors can hope or expect to accomplish by their Lectures is, by laying before the pupils, with clearness and perspicuity, the leading principles of the science they teach, to prepare their minds for the reception and investigation of medical truths. The Professor merely lays the foundation on which the Student is afterwards, by his own diligence, observation, and study, to raise himself to eminence and usefulness in his profession. With the exception of Anatomy, therefore, all a Student can expect to acquire during the term of his attendance on Lectures, is merely the great outlines of Medical Science. But this season, unfortunately, by the regulations of the Medical Schools of our country, a very limited one, is the only period that he will ever have for the acquisition of anatomical knowledge. Anatomy, the basis of all medical reasoning, can only be studied *practically*, during the term of the Student's attendance on Lectures. Should he neglect his opportunities for acquiring a competent knowledge of the science during the term passed by him at College, he must be content to continue forever afterwards a mere driveller in his profession. Now, Anatomy is not to be learnt by an attendance on Lectures. Dissection, and dissection alone, can make a man an Anatomist. The Professor of Anatomy, it is true, may by animated and masterly demonstrations, do much to guide and assist the anatomical Student in the prosecution of his studies, but it is in the Dissecting Room, with the dead body before him, by patient and assiduous dissection, that the Student can alone acquire a knowledge of Anatomy." (Annual Announcement, Jefferson Medical College, Philadelphia, 1832, pp. 4–6.)

Unfortunately here, as in so many other institutions, the time of the professor was soon so taken up by private practice that he was unable to devote that personal attention to his classes in dissection necessary for the best results.

Other well known professors at the Jefferson Medical College have been, J. Pancoast, W. H. Pancoast, and W. S. Forbes.

Of the considerable number of *private schools organized in Philadelphia* (J. Parish and R. Harlan, in 1818, T. Hewsen, in 1822, Dr. G. McClellan, in 1829, all started schools of this kind), the most celebrated is the Philadelphia School of Anatomy, which lasted from 1820 to 1875.

W. W. Keen has given in his "*History of the Philadelphia School of Anatomy*," 1875, a most interesting account of this important school. It accomplished a great mission. "Within its walls earnest, intelligent laborious men of science taught, experimented and investigated, and published the results of their work in many a book and pamphlet, while thousands of men who studied and dissected there, and there began their scientific lives, are spread all over the country, and in fact all over the world, doing the best of work as practitioners, teachers, writers, and original investigators."

The School was opened in 1820 as the private anatomical school of J. V. O. Lawrence (1791–1823), under the name of the "Philadelphia Anatomical Rooms." "At that time the University (then the only medical school) closed its doors in April and they remained unopened till November. . . To fill out this long hiatus Lawrence, a graduate of the University of Pennsylvania, opened his school and gave a course in Anatomy and Surgery, which began in March, had a recess in August, and ended in November. He gave six lectures a week. In 1822 he was made assistant to Dr. Horner, then Adjunct Professor of Anatomy at the University of Pennsylvania." "Like most of his followers in the school, not satisfied with teaching, he was also a frequent writer as well as active in original investigations and experiments." In 1822, assisted by Drs. Harlan and Coates he performed over ninety experiments on animals to test the absorbent action of the veins and in the following year over one-hundred.

The second head of the school was Dr. John D. Godman, who previously has been professor of anatomy in the Medical College of Ohio. Dr. Godman retired from practice in 1823 when he began teaching in the School. As was the custom for many years afterwards he gave three courses a year, viz.: the autumn course, twice a week from September to November; the winter course, four times a week from November to March; and the spring course, twice a day (with a view to graduation) from March 1 to April 1; the remainder of the year being a vacation in teaching, but devoted to work. The fee for each course was ten dollars." In 1824 Godman established in connection with the school a reading-room and library. Dr. Godman was one of the founders of the American Journal of the Medical Sciences and published in three volumes a "Natural History of American Quadrupeds," and among many other works a book on the "Fasciae," one on "Physi-

ological and Pathological Anatomy," and a paper on "Arterial and other Irregularities." Dr. Godman was called to Rutgers College in 1826 and was succeeded by Dr. James Webster, who in 1830 was called to the Geneva Medical College.

In 1831 Dr. Joseph Pancoast re-opened the rooms and taught there for seven years. In 1838 he became professor of anatomy in the Jefferson Medical College. He translated and edited several foreign books and prepared a new edition of Horner's Anatomy while at the Philadelphia School.

Dr. Pancoast was succeeded by J. Dunot and J. M. Allen, the latter of whom published a Dissector's Manual. The first woman to dissect there joined the class in 1843–4. "'It was probably,' says her sister, 'the first time that a woman had dissected as a medical student.'"

Dr. D. Hayes Agnew assumed the responsibilities of the school in 1852 and held it for ten years. He was found a most inspiring teacher. "While teaching here he published his "Dissector's Manual" and a series of papers on Anatomy in its Relation to Medicine and Surgery. In 1862 Dr. Agnew relinquished the anatomical department to Dr. J. E. Garretson, who was followed in turn by J. P. Andrews and R. S. Sutton and finally by W. W. Keen who once more reestablished the brilliant reputation of the school as may be judged from the following quotation from his farewell speech:

"It ill becomes one to speak of himself, but I may perhaps be permitted to state the following facts: I have lectured here longer than any of my predecessors, Allen and Agnew only excepted; I have given nine winter and five summer courses of Descriptive and Surgical Anatomy, two courses on Artistic Anatomy, and thirteen courses on Operative Surgery, besides private courses to numerous individual students and graduates. I have had nearly fifteen hundred students of whom at least five are already professors in medical colleges, and one has opened the first dissecting-room ever established in Japan. They have come from the District of Columbia, and every State in the Union, except New Mexico and Nebraska, and from fourteen foreign countries, as follows: Canada, Nova Scotia, Prince Edward's Island, New Brunswick, Cuba, Porto Rico, Mexico, Costa Rica, Nicaragua, Denmark, Norway, Prussia, Switzerland, and England.

"From 1866 to 1870 I occupied only the western building, Dr. Richardson having the lower story of the other for his Quiz Class, and Dr. H. Lenox Hodge, from 1868 to 1870, the upper story for his courses in Operative Surgery, but in order to accommodate my increasing classes I was obliged, in 1870, to obtain the use of both buildings, and later still

further to enlarge the lecture-room by placing the gallery over my head, while many, even then, were unable to obtain seats. During this time, also, I have published a series of Clinical Charts of the Human body, a sketch of the Early History of Practical Anatomy, and a pamphlet on the Anatomical, Pathological, and Surgical Uses of Chloral (which I deem my most important contribution to practical Anatomy). I have edited also Flower's Diagrams of the Nerves and Heath's Practical Anatomy, and have published anatomical and surgical papers on a new diagnosis of Fracture of the Fibula, on the Anatomy of Optic Chiasm (with Dr. William Thomson), on the Ossification of the Atlas Vertebra, on a case of Asymmetry of the Skull, on a Malformation of the Brain, on the Physiology of the Inferior Laryngeal Nerves and the Intercostal Muscles in a case of judicial hanging, and numerous other general medical articles, besides gathering the material for several other papers and perhaps more extended publications." (History of the Philadelphia School of Anatomy, by W. W. Keen, Philadelphia.)

Among others more or less closely associated with the Philadelphia School of Anatomy during the last twenty-five years of its existence were J. F. Meigs, the well known obstretician, S. Weir Mitchell, who began his work on snake venum in the building occupied by the school, and "with G. R. Morehouse discovered the extraordinary chiasm in the inferior laryngeal nerves in chelonia," and Dr. Brinton, who discovered a method of preserving fresh anatomical specimens by applying guttapercha dissolved in benzole, published an excellent paper on dislocations of the sternum and discovered the right spermatic vein. Harrison Allen also carried on some of his studies in comparative anatomy in the building occupied by this school. Many of the foremost physicians of this country received an important part of their training at the school. It was the one institution for medical education in this country previous to very recent years where scientific research held real position. Even medical students were encouraged to investigate. Thus the valuable statistical study of the brachial plexus made by Walsh (Am. Jr. Med. Sc., 1877, vol. LXXIV, p. 387) was begun here at Keen's suggestion.

At the Pennsylvania Medical College (the medical department of the Pennsylvania College at Gettysburg) which was founded in Philadelphia in 1839 and discontinued in 1861, S. G. Morton was professor of anatomy 1839–43. Morton gathered together a splendid collection of skulls and published among other works "Crania Americana," 1839, Crania Aegyptiaca (1844), Ethnology and Archaeology of the American Aborigines, 1846, and an Illustrated System of Human Anatomy, 1849.

At *Harvard*, John Warren, from 1782 to 1815, and John Collins Warren from 1815 to 1843, were professors of anatomy and surgery, and O. W. Holmes, from 1847 to 1882, professor of anatomy and physiology. The two Warrens, although men interested in surgery rather than in anatomy, were men of broad interests and did much to build up the anatomical museum now named after John Warren.

. T. Dwight, who has been professor of anatomy there since 1883 has been an active contributor on anatomical subjects (see note 21).

Corydon La Ford, professor of anatomy at Michigan, from 1854 to 1893, was much liked as a teacher. Previous to the adoption of the graded course he gave instruction in several institutions successively each year. This he continued to do for a time in spite of the fact that his salary was raised in order to make it unnecessary for him to teach elsewhere. (Vid. Am. State Universities and the Univ. of Mich., 1875, p. 264.)

For an account of the early history of anatomy in this country, in addition to the two papers by W. W. Keen, "A Sketch of the Early History of Anatomy," 1874, and "the Philadelphia School of Anatomy," 1875, reference may be made to E. M. Hartwell's "Study of Human Anatomy" (Studies, Biological Laboratory, Baltimore, 1881), and "Hindrances to Anatomical Study in the United States" (Annals of Anatomy and Surgery, Brooklyn, 1881), and Carson's "History of the Medical Department of the University of Pennsylvania."

17, (p. 97). MICROSCOPIC ANATOMY.

American anatomists played no part in that early development of histology, embryology, and cytology which in the hands of the European and especially the German anatomists contributed during the middle of the last century so greatly to the advancement of practical medicine no less than of pure science. A little of this new knowledge drifted into this country in a tardy fashion.

Up to 1840 the microscope was so little used in America that when the government exploration expedition, known as the Wilkes Expedition, set forth in 1838, no microscope could be bought in this country and one was borrowed from Dr. P. Goddard of Philadelphia. (Vid. Debt of American Microscopists to Spencer and Tolles. Trans. Am. Mikr. Soc., 1901–2.) In 1838 C. A. Spencer announced himself as a manufacturer of microscopes at Canastota, N. Y. Both he and his pupils R. B. Tolles and H. R. Spencer made good instruments and introduced some improvements in the construction of microscopes. Thus

Tolles discovered a method of cover-glass correction for objectives and was the first to use homogeneous immersion lenses.

The microscope during the fourth, fifth, and sixth decades of the last century was, however, for the great bulk of Americans who used it a pretty toy rather than an aid to scientific discovery. For example, "Dr. Cheever has said: 'Dr. Holmes was one of the early microscopists, and was a very good one. The instrument was not among the tools of the instructing physicians when he was studying in Paris (1833–1835), but soon afterwards it came into general use. He brought one home with him from Europe. It fascinated him, as indeed it did many another. He had a great taste for everything ingenius, and playing with this new machine devoured many an hour. He was forever taking his own to pieces and putting it together, and trying all sorts of experiments with it, both as to the mechanism itself, and as to subjects of examination. How well I recollect the intense absorbtion with which he would thus pass long hours! Hours which were not wasted, 'for he was no mean authority on this subject in his day.'" (Morse, J. T. Life and Letters of Oliver Wendell Holmes, 1896, Vol. I, p. 183.) Thus popular demand led to the construction of elaborate expensive instruments rather than to that of simple serviceable ones. The microscopes made in recent years in America are copied closely after the simple German models.

An exception to the general run of the early American microscopists, Professor Bailey of West Point, early in the forties, achieved marked European distinction for his work on the infusora. S. Wyman likewise in 1843 utilized the microscope with effect in the study of the teeth of Lepidosteus. The first mention I find made of the use of the microscope in a medical school is the announcement made in the catalogue of Dartmouth College for 1848 that the professor of anatomy there had a Chevalier microscope for demonstrating the microscopic structure of the tissues. In 1860 the Berkshire Medical School announced that thorough instruction in the use of the microscope would be offered by Professor Stiles, and in 1863 use of the microscope was advertised at the Harvard Medical School. In 1869 the Philadelphia School of Anatomy advertised that "the microscopic anatomy of the various tissues will be shown by the class microscope." At about the same period special instruction in the use of the microscope was offered by the professor of anatomy at the University of Michigan, for a fee of $5.00. According to His (Vesalianum, Basel, 1885, p. 29), the microscope was introduced into the German medical schools in the fifties, yet he himself as a student in one of the larger German universities

had to stand in a line of a hundred men which slowly filed passed a demonstration microscope.

During the sixties the more scientific physicians of the country were making some use of the microscope. Thus about 1860 J. M. Da Costa, while giving private courses in medicine in the building of the Philadelphia School of Anatomy, translated v. Kölliker's Microscopic Anatomy from the German. During the seventies demonstration of microscopic structure began to be a regular part of the instruction in the better schools. Thus the Yale catalogue announces for the year 1872–3: "microscopy, histology and pathology, illustrated by a sufficient number of compound microscopes and a large collection of the best preparations. It is believed that no institution in this country furnishes to students greater facilities for acquiring exact knowledge in this department."

Many devices were utilized for demonstrating numerous sections quickly to large numbers of students. Thus for instance in some schools microscopes were placed on a track which ran around on a table at which a section of the class stood or sat. The microscope could in this way quickly be passed from one student to the next.

A thorough training in microscopic anatomy began to be offered only after the establishment of a graded curriculum and then usually rather in connection with pathology than with anatomy. Previous to this time, however, several private laboratories were opened for instruction in microscopic technique. Thus C. Heitzmann, who had been a private docent at Heidelberg, in 1874 opened a private laboratory for microscopic investigation in New York City. Heitzmann was one of the earliest to declaim the inadequacy of the cell theory when applied to certain animal structures. In his laboratory a considerable amount of investigation was done. In a book on the "Mikroscopiche Morphologie des Thierkörper," published in 1883, he gives a list of the investigators who had studied in his laboratory and of their publications.

18, (p. 98). REFORM IN MEDICAL EDUCATION.

Throughout the long period of low standards of medical education in this country there was much talk of reform at various meetings of medical societies. "In May, 1867, there was held in Cincinnati a convention of delegates from the medical schools of the country and resolutions were passed recommending changes in the methods of study, advising four years of study instead of three. 'These propositions,' says Dr. H. A. Johnson, 'no doubt faithfully represented the opinions

of those teachers when at a distance from their institutions, but they had altogether a different set of ideas when the question was presented in its financial aspects at home.'" (Report Illinois State Board of Health, 1891, p. xxxii.) The Association of American Medical Colleges formed in 1877 likewise failed to bring about a reform.

Meanwhile the establishment of a graded course was initiated by the Chicago Medical College, now the medical department of the Northwestern University. This college upon its organization in 1859 offered a graded course of study extending over three years. Students were, however, allowed to graduate upon hearing lectures for two years. The reform in reality was chiefly brought about by the changes introduced at the Harvard Medical School after Charles W. Eliot became president of the University. In 1871 a three years graded course of nine months each year was established in this school. In 1880 a four years graded course was offered, and after 1892–3 it was required. In the medical department of Syracuse University, opened in 1877, a three years graded course of nine months each year was required; and in the same year the course at the University of Pennsylvania was changed to a three years graded course of five months each year. Michigan adopted the three year course in 1880.

In 1880 the Illinois State Board of Health adopted its schedule of minimum requirements to go into effect after the session of 1882–83. These were in advance of the requirements for a degree at most of the medical schools but still considerably below that of the institutions above mentioned. They required three years of medical study during two years of which courses of lectures must be attended in a medical school of approved standing. The courses must be at least five months long and instruction must include dissection and clinical instruction. In 1887 the standards were raised to take effect in 1891, to four years of medical study with attendance at a medical school during three years of this time. At present attendance at four annual sessions of six months each is required by this board as well as by the State Board of Medical Examiners in a large number of the States. Of these the New York Board has taken the lead in demanding increasingly higher standards. The branches of medical science included in the course are: anatomy, physiology, chemistry, materia medica and therapeutics, theory and practice of medicine, pathology and bacteriology, surgery, obstetrics, gynecology, hygiene, and jurisprudence.

While the State Boards have thus played some part in raising the standards of medical education they have not always shown either fairness or wisdom in the rules they have adopted. Thus for instance the Minnesota Board has made a ruling that colleges giving advanced

standing for work in non-medical colleges are not recognized. If, for instance, a medical school which has the highest standards of education, grants an M. D. degree to a man who has studied there for three years after having previously studied physics, chemistry and biology, including human anatomy and physiology, for four years in a leading non-medical college or scientific school, not only this individual but all other subsequent graduates of that medical school will be debarred from practice in Minnesota. Yet this individual is exceptionally well educated and the other graduates are obviously far better prepared than the majority of those who are examined for their fitness to practice in that State.

Furthermore the State examinations are mere written tests of memory cram, not thorough examinations of fitness for practice. Still on the whole the State Board examinations have worked for the advance of medical education. (An abstract of the State laws regulating the practice of medicine is published by the American Medical Association, Chicago.)

Good work has been accomplished by the American Medical Association, and by the Association of American Medical Colleges, founded in 1890. To this latter association only those colleges are admitted which maintain a certain standard of excellence in their educational requirements and these standards have been rapidly raised since the formation of the society. Special mention should be made of the late Dr. N. A. Davis of Chicago who fought most valiantly to bring about the much needed reform.

The Illinois State Board of Health published in 1891 a valuable pamphlet on Medical Education and Medical Colleges in the United States and Canada. While conditions have been wonderfully improved since the pamphlet was written, there are still far too many schools inadequately equipped with material, men and ideals, and far too few schools where high standards of education and scientific excellence are maintained. (See L. F. Barker, Medicine and the Universities, American Medicine, 1902; J. M. Dodson, The Modern University School, Journal of the American Medical Association, Sept. 6, 1902; H. L. Taylor, in Parson's "Professional Education in the United States, Medicine," 1900, p. 351, published by the University of the State of New York: Dexter, "History of Education in the United States," 1903.)

The introduction of laboratory methods of instruction in the medical sciences and the development of more practical clinical instruction has caused a demand for a better preliminary education than was previously considered necessary. A four years high school course is now required as a preliminary for entrance into any respectable school. At

Columbia since 1902 about one year of college work has been required. A similar requirement is made at the Cornell Medical School and at the University of Minnesota. At the University of Michigan and at Chicago-Rush Medical School since 1902 about two years have been required. A similar requirement goes into effect next fall at the University of California. At the Western Reserve University since 1901 three years of college work have been required, and at the Johns Hopkins since 1893, and Harvard since 1901, the diploma of a recognized college or scientific school or its equivalent.

For entrance into the Johns Hopkins Medical Department the preliminary work must include a training in French, German and Latin, chemistry, physics and general biology. This is the only institution which, as yet, requires so extensive a preparation, although scientific training in biology, physics and chemistry, as a good preliminary training for medical study, was offered at Harvard University after the establishment of the Lawrence Scientific School in the fifties. Similar opportunities were afterwards offered at other institutions. Special preliminary courses leading up to the study of medicine were established at the Universities of Pennsylvania, Cornell, Yale, Princeton, Lake Forest, Northwestern University, the Johns Hopkins University, the University of Wisconsin and other colleges. As a rule these preliminary courses, usually extending over two years, were found to be over-crowded with subjects. (See Report U. S. Bureau of Education, 1881, and 1892-3, pp. 601-13.)

At Harvard in 1884, 53.9 per cent of the students of medicine were college graduates; in 1889, 34.4 per cent; in 1893, 23 per cent. (Medical Education, Rept. U. S. Bureau of Ed., 1892-3.) This steady decline in the ratio of college graduates to the total number of medical students does not indicate an increasing public appreciation of the value of a college training as a preliminary for medical studies. As a matter of fact most of those institutions which have put up high entrance requirements have suffered a severe loss in the number of attending students. On the other hand Dexter in his "History of Education in the United States," 1903, has pointed out that of those who have made a marked success in medicine a proportionafely very large number have graduated from literary and scientific colleges previous to the study of medicine.

19, (p. 98). INTRODUCTION OF LABORATORY METHODS.

Michigan claims the credit of having opened the first laboratories for medical instruction in this country. Chemistry was taught there by

the laboratory methods in the fifties. Laboratory methods in histology and physiology were adopted in 1877 and in hygiene and bacteriology in 1888. At Harvard laboratories for physiology, histology and pathology were opened in 1871 for regular class work, although it was not until a new building was acquired in 1883 that adequate laboratory facilities were furnished in these subjects. During this period from 1871 to 1883 $320,000 were added to the funds of the medical school by bequests and gifts. This shows the public appreciation of the advanced stand Harvard was taking.

20, (p. 98). SCIENTISTS IN THE MEDICAL SCHOOLS.

In Note 15 we have pointed out that the Philadelphia School of Anatomy served as an active center of research as well as a school of instruction. At the University of Pennsylvania and other institutions some of the instructors were scientifically active men, but in general little encouragement was given to research and what was done was accomplished through much self-sacrifice.

At Harvard H. T. Bowditch, fresh from the scientific atmosphere of Germany, was made assistant professor of physiology in 1871 and professor in 1876. In the catalogue for 1871 and subsequently he offered to 'third class students opportunities for original investigation in the laboratory," the first published indication in America of university ideals in undergraduate medical education. Harrison Allen, professor of physiology at Pennsylvania, (1878–85), was enthusiastically in favor of research. C. H. Stowell introduced class work in histology, in 1880, and Henry Sewell scientific physiology, in 1883, at Michigan. W. H. Welch at the Bellevue Medical School and T. M. Prudden at Columbia did much to introduce the new German pathology into America in the seventies and early eighties. When Welch became professor of pathology at the Johns Hopkins University, in 1884, he established there a research laboratory which has since served to train several of our leading pathologists and to advance the science in America. At Harvard C. S. Minot during the eighties introduced thorough courses in histology and embryology.

The influence of these men and of several of their contemporaries has since led to a rapid advance of the sciences of physiology, histology, and pathology in the medical schools. Unfortunately, however, human anatomy continued in the main in the hands of surgeons unacquainted with the subject as a science. Only too often histology and embryology have not been thoroughly understood by the professor of anatomy, and

have been either handed over to the physiological and pathological departments or established as separate subjects uneo-ordinated with gross anatomy. While it would certainly be a distinct loss if anatomy were not cultivated by physiologists, pathologists and clinicians in those aspects which bear most closely on their fields, it is equally certain that an anatomical department should embrace microscopic anatomy and the study of organic development as well as gross anatomy. Otherwise but a narrow, unproductive attitude toward the science can be maintained.

21, (p. 99). ENDOWMENT OF MEDICAL SCHOOLS.

Since the establishment of numerous well-equipped laboratories and the employment of well trained men to devote their whole time to the care of the laboratories, to teaching and research, the expenses of the better schools have so increased as to make the fees of the students, even when raised to $200 a year, as at Harvard and the Johns Hopkins University, and $250, as at Columbia, utterly inadequate to meet the fixed charges. Large endowments or State support are absolutely necessary for a proper system of medical education.

The following table, based upon the Report of the Commissioner of Education, shows the number of colleges and universities, professional and technical schools in the United States in 1875–76 and in 1901–2, the number of instructors, students, and books in the library, and the estimated value of grounds and buildings, amount of productive funds, income from productive funds, income from tuition and fees, state and federal appropriations, and the amount of benefactions for the two years. The figures relative to the number of institutions, students and instructors, are probably fairly accurate. The figures relative to grounds, buildings, endowment and income are but imperfect approximations. So far as possible the number of institutions on which the data are based is given in each instance.

In this table under universities and colleges are included all co-educational institutions and all institutions devoted to the education of men and the higher grade of colleges devoted exclusively to the education of women. All professional schools are included under the respective headings, but only those technical schools of agriculture and engineering which are not university departments are classed as technical schools. The data for the technical schools for 1875–6 are taken from page CXVIII of the Report of that year. It is not, however, perfectly clear that the figures there given under the head of schools of science refer to technical schools as defined above.

TABLE A—NOTE 21.

	Year.	Number reported.	Universities and Colleges.	Number reported.	Technical Schools.	Professional Schools. Number reported.	Of Theology	Number reported.	Of Law.	Number reported.	Of Medicine.
No. institutions	1875-6	355	355	43	43	123	123	43	43	80	80
	1901-2	477	477	43	43	148	147	102	102	154	154
No. instructors	1875-6	342	3,286	.....	415	118	615	41	224	80	981
	1901-2	477	9,511	43	1,319	147	1,034	102	1,155	154	5,029
No. students	1875-6	304	26,353	.....	3,649	116	5,163	39	2,677	73	8,580
	1901-2	477	89,030	43	13,040	148	7,343	102	13,912	154	26,821
No. books in library	1875-6	288	1,806,173	.....	43,727	87	599,177	3	52,311	42	62,970
	1901-2	475	[1]9,006,174	42	[2]494,981	118	1,527,156	70	386,905	68	156,929
Est. value, grounds, bldgs., appar'tus	1875-6	321	$41,076,105	.....	$3,924,109	73	$6,268,115	3	$45,000	59	$3,154,350
	1901-2	471	180,475,537	42	27,511,902	116	15,705,710	27	1,670,000	102	12,986,642
Amount of productive funds	1875-6	189	33,252,585	...	5,591 128	79	8,415,601	21	58,201	38	220,266
	1901-2	438	170,441,470	33	14,454,783	100	23,058,877	34	486.001	60	2,132,568
Income from productive funds	1875-6	181	2,453,336	.....	403,945	77	529,204	9	17.695	38	15,771
	1901-2	421	7,612,060	31	587,039	.....	.....	.....	.....	.....	.....
Income from tuition and fees	1875-6	254	2,136,062	.....	70,093	.....	.....	14	52,944	52	364,552
	1901-2	416	10,527,174	33	610,387	.....	.....	.....	.....	.....	.....
State appropriations	1875-6	29	[3]667,521	.....	168,277	.....	.....	.....	.....	.....	.....
	1901-2	413	5,100,331	35	1,266,999	.....	.....	.....	.....	.....	.....
Federal appropriations	1875-6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	1901-2	412	995,413	30	1,954,185	.....	.....	.....	.....	.....	.....
Total income	1875-6	.....	5,256,919	.....	672,621	.....	.....	14	70,639	52	380,323
	1901-2	421	26,800,162	42	4,796,613	79	1,414,724	38	522,763	70	[4]1,356,600
Benefactions	1901-2	284	16,307,300	.....	426,783	66	1,269,433	24	52,859	48	160.584

[1] In addition there are 2,281,478 pamphlets. [2] In addition there are 140,312 pamphlets. [3] Federal and state appropriations are probably here combined. [4] Figures for 1901. The figures given in the report for 1902 are more incomplete.

In number during the period under consideration the schools of law were more than doubled, those of medicine nearly doubled, the colleges and universities increased about a third, the schools of theology about a sixth and the independent technical schools apparently remained constant.

The number of instructors increased over five-fold in the medical schools, about five-fold in the law schools, over three-fold in the technical schools, less than three-fold in the universities and colleges and less than two-fold in the theological schools.

The number of students increased about five-fold in the law schools, nearly four-fold in the technical schools, over three-fold in the universities and colleges, about three-fold in the medical schools and less than fifty per cent. in the theological schools.

In 1870 the population of the country according to the United States census was 38,558,371; in 1880, 50,155,783; in 1890, 62,622,250; and in 1900, 76,303,387. During the period under consideration, 1876–1902, it is safe to assume that the population less than doubled. The number of those seeking a higher education has therefore increased much faster than the population, in spite of rapidly increasing standards of the universities and professional schools.

The data relating to the libraries, value of equipment and grounds, endowment funds and income are so incomplete that comparisons similar to those given above cannot be well made. It is evident, however, that great progress has been made in all of these directions. The most favored institutions are the technical schools, the income of which seems to have increased perhaps seven-fold, although the number of students increased but four-fold. The income of the law schools increased with a similar rapidity but in them the increase in the number of students was more rapid. In proportion to the increase in the number of students the income of the colleges and universities has increased more rapidly than that of the medical schools.

From the United States Census for 1900 (Statistical Atlas, plates 128 and 180) it may be estimated that the value of farm lands doubled during the period under consideration (from nine to eighteen billions) and that of capital invested in manufactures increased four-fold (from two and a half to ten billions of dollars). It is certain, I think, that the value of the equipment, buildings and grounds and that of the productive funds of institutions for the higher education has increased in a ratio greater even than that of the capital invested in manufactures. The evident rapid increase in the vested funds devoted to medical education is one of the most encouraging features.

The success that has followed the endowment of a hospital for med-

ical teaching by Johns Hopkins and for the associated medical school by Mary Garrett and others; the gifts to the medical departments of Columbia University, at New York, and the Western Reserve University, at Cleveland; the more recent endowments of the medical departments of Cornell University at Ithaca, N. Y., and of Tulane University at New Orleans; the gifts for the medical science building at Pennsylvania, the establishment of the Rockefeller Institute and the recent magnificent gifts for the Harvard Medical School, it is to be hoped indicate a tendency on the part of public spirited citizens to endow medicine as it should be endowed. We must also expect far more liberal support from the State. In no way does the public pay more dearly for its lack of liberal support of educational institutions than in its attitude toward medicine. It is a debt paid not only with money but with life. (See W. H. Welch, Higher Medical Education and the Needs of its Endowment, Medical News, July 21, 1894; L. F. Barker, Medicine and the Universities, American Medicine, 1902.)

TABLE B, NOTE 21.

University.	Situation.	Number of Professors.	Number of Instructors.	Number of Students.	Value of grounds and buildings.	Value of endowments.	Annual income.	Tuition.
Harvard[1]	Boston, Mass	32	111	506	$600,000	$1,000,000	$163,000	$200
Columbia	New York.....	36	66	827	2,250,000	478,227	[4]190,000	200
Johns Hopkins[2] ..	Baltimore, Md...	18	21	229	171,000	426,866	[4]63.000	200
Western Reserve .	Cleveland, Ohio.	26	18	126	300,000	200,000	26,000	125
Pennsylvania	Philadelphia, Pa	28	43	542	....	?	[4]120,000	200
U. of California ..	S'n Fr'ncisco, Cal	19	20	140	300,000	?	25,536	150
Northwestern.....	Chicago, Ill.....	38	15	465	225,000	50,000	63,913	135
Rush[3]	Chicago, Ill.....	22	115	792	375.000	?	65,000	137

[1] Harvard University has under construction a set of five buildings which will far exceed in beauty and fitness any at present in this country. The buildings are expected to cost $1,800,000 and the equipment $50,000. An endownment fund of about $3,000,000 has likewise been provided for Of the large sum of money which it was necessary to raise for the buildings and toward increasing the endowment, Mr. J. P. Morgan contributed $1,135,000, Mr. J. D. Rockerfeller $1,000,000, Mrs. A. D. Huntington $250,000, Mr. J Stillman $100,000. and numerous generous friends of the college have made up the remainder. (Vid. Report of the President and Treasurer for 1901-2.)

[2] The Johns Hopkins Hospital, with an endowment of $3,500,000, is essentially a part of the school.

[3] The first two years of a four year course are spent at the University of Chicago.

[4] Unofficial estimate.

The majority of the medical schools have no endowment and considering the wealth of the country there is as yet no school endowed as liberally as it should be, no institution adequately supported by the State. The preceding table indicates the number of students studying

medicine, the number of professors and instructors, the estimated value of the buildings, and the total income of a few of the best supported schools in 1901–1902. It is based primarily on the Report of the Commissioner of Education for 1902. In several of the institutions there has been a marked decrease in the number of students since that date. This is owing in part to higher standards of admission.

At the other end of the scale are such institutions as the Knoxville Medical School with eight professors, two instructors, twenty-one students, a tuition fee of $37.00 and a total annual income of $790.00, and the Woman's Medical College, Baltimore, with sixteen professors, eight instructors, twenty-five students, and an annual income of $1,818.00.

Unfortunately the majority of educational institutions either publish no financial reports or, like most of the State universities, publish them in such a form that no adequate knowledge can be gained of the funds and running expenses of the various departments.

22, (p. 99). SCIENTIFIC ANATOMICAL LABORATORIES IN MEDICAL SCHOOLS.

(A) PRODUCTIVENESS.

In Note 15 I have spoken of the scientifically productive anatomists who held chairs in medical schools previous to the eighties. Of recent years the number of such men has greatly increased.

At *Harvard* T. Dwight was instructor in histology and later in topographical anatomy previous to becoming professor of anatomy in 1883. Professor Dwight has been a more extensive contributor to the science of human anatomy than any of his predecessors in this country, and has used more extensively than heretofore the material of the dissecting room for scientific studies of variation, especially in the fields of the muscular and skeletal systems. He has added extensively to the anatomical museum and has established a valuable collection of skeletons to illustrate structural variation. He was also the first in the country to make use of frozen sections of the body and in his laboratory S. F. Mixter introduced digestion for the corrosion of injected specimens. Among others who have contributed from Professor Dwight's laboratory may be mentioned S. W. Allen, E. A. Codman, assistant in surgery, Harvard, F. Dexter, H. A. Lothrop, instructor in surgery, Harvard, R. W. Lovett, assistant in orthopedics, Harvard, H. P. Mosher, assistant in anatomy, Harvard, O. K. Newell, B. Tenney and J. Warren, demonstrator of anatomy, Harvard.

C. S. Minot, who became instructor of histology and embryology in 1883, assistant professor in 1887, and professor in 1892, was the first in this country to give these subjects their proper position in the medical curriculum, and among the first to encourage by example advanced research in these fields. He has done much to advance the study of morphology not only in medical schools, but also in the collegiate departments of our universities. The collection of vertebrate embryos prepared for microscopic study under Dr. Minot's direction at the Harvard Medical School is probably the best and most complete of its kind in the world. The use of this collection is freely offered to trained investigators. Among those who have made contributions from Professor Minot's laboratory may be mentioned R. T. Atkinson, J. F. Bower, J. L. Bremer, instructor in histology, Harvard Medical School; F. Dexter, A. C. Eycleshymer, professor of anatomy, the University of St. Louis; F. T. Lewis, instructor in histology, the Harvard Medical School; G. C. Price, assistant professor of embryology, Leland Stanford University; A. Shaper, professor of anatomy, the University of Breslau, Germany; F. A. Woods, E. Taylor and J. Warren.

At the *University of Michigan*, G. C. Huber, who became assistant demonstrator of histology and embryology in 1887, assistant professor in 1893, and professor in 1902, and J. P. MacMurrich, professor of anatomy since 1893, have made the anatomical laboratories there noted for their scientific productions. Lydia M. DeWitt, instructor in histology and embryology, has likewise done important work. A. H. Roth, R. C. Bourland and E. W. Adamson have also contributed.

At the *University of Pennsylvania*, G. A. Piersol, demonstrator of histology and embryology, 1884–89, professor, 1889–91, and professor of anatomy, 1891–, has contributed to embryology and teratology and is the author of a favorite text-book on histology. From 1901 to 1904 E. H. Gregory, now professor of anatomy at the Northwestern University, was assistant professor of anatomy.

At *Columbia*, G. S. Huntington, assistant demonstrator of anatomy, 1886–89, lecturer, 1889–1890, and professor since 1892, has been the first in the country to realize the full importance of comparative anatomy to human anatomy and has built up a splendid museum for the purpose of instruction and research. Among those who have made contributions from this laboratory may be mentioned J. A. Blake, instructor in surgery, Columbia; C. Carmalt, assistant demonstrator of anatomy, Columbia; B. B. Gallaudet, instructor in surgery, Columbia; A. Hrdlicka, curator of anthropology, National museum; E. A. Spitzka; and A. S. Vosburgh, assistant demonstrator of anatomy, Columbia.

The value of a museum for medical instruction has been treated of

by Professor Huntington in Science, vol. 9, 1899; vol. 13, p. 601, 1901, and Am. Journal Med. Science, 1898.

Since 1890 many appointments to professorships in anatomy, histology and embryology have been given to men whose aim is to advance the subject in its scientific aspects.

Among them may be mentioned in addition to those named above, R. D. Whithead, professor of anatomy, the University of North Carolina, 1890; W. Keiler, professor of anatomy, Texas, 1892; T. G. Lee, professor of histology and embryology, Minnesota, 1892; F. P. Mall, professor of anatomy, the Johns Hopkins University, 1893; R. J. Terry, professor of anatomy, Washington University, St. Louis, 1895; W. S. Nickerson, assistant professor of histology, Minnesota, 1897; A. T. Kerr, professor of anatomy, Cornell, 1898; C. M. Jackson, professor of anatomy, Missouri, 1899; R. G. Harrison, associate professor of anatomy, Johns Hopkins University, 1899; L. F. Barker, professor of anatomy, Chicago, 1900; R. R. Bensley, assistant professor of anatomy, Chicago, 1901; J. L. Flint, professor of anatomy, and I. Hardsty, assistant professor, California, 1901; A. C. Eycleshymer, professor of anatomy, University of St. Louis, 1902; G. H. Hoxie, assistant professor of anatomy, Kansas, 1902; F. C. Waite, assistant professor of histology and embryology, Western Reserve University, 1902; B. G. Meyers, associate professor of anatomy, University of Indiana, 1903; A. C. Pohlman, assistant professor of anatomy, University of Indiana, 1904; E. H. Gregory, professor of anatomy, Northwestern University, 1904; W. H. Lewis, associate professor of anatomy, Johns Hopkins University, 1904.

The next step in advance has come from offering the positions of demonstrators, instructors and assistants to young men interested rather in the development of the science than in exploiting it for the sake of surgery. The establishment of a well endowed school in connection with the Johns Hopkins University gave Professor Mall this opportunity which he has utilized most successfully. His example has been followed in a number of other institutions and is likely to be followed in all the better schools. Research on the part of graduates and undergraduate students of the medical schools has at the same time been greatly encouraged.

The following in addition to Professor Mall have made scientific contributions from the anatomical laboratory of the Medical Department of the *Johns Hopkins University:* C. R. Bardeen, professor of anatomy, the University of Wisconsin; L. F. Barker, professor of anatomy, the University of Chicago; R. B. Bean, assistant in anatomy, Johns Hopkins University; H. M. Berkely, clinical professor of psychiaty, Johns Hopkins University; J. M. Berry; C. E. Brush; H. A. Christian, instructor

in pathology, Harvard Medical School; W. J. Calvert, assistant professor of medicine, the University of Missouri; J. G. Clark, professor of gynecology and obstetrics, the University of Pennsylvania; A. W. Elting; J. M. Flint, professor of anatomy, the University of California; H. A. Fowler; R. G. Harrison, associate professor of anatomy, the Johns Hopkins University; P. K. Gilman; G. L. Hendrickson; M. Herrington; E. C. Hill; J. M. Hitzrot; A. G. Hoen, professor of pathology, Richmond, Va.; A. T. Kerr, professor of anatomy, Cornell University; W. B. Johnson; H. McE. Knower, instructor in anatomy, Johns Hopkins University; W. H. Lewis, associate professor of anatomy, the Johns Hopkins University; E. L. Mellus; J. B. MacCallum, associate professor of physiology, the University of California; A. W. Meyer; B. D. Meyers, associate professor of anatomy, the University of Indiana; A. G. Pohlman, assistant professor of anatomy, the University of Indiana; R. L. Randolph, professor of ophthalmology, the Johns Hopkins University; F. R. Sabin, associate in anatomy, the Johns Hopkins University; Dr. E. Stieren; G. L. Streeter, instructor in anatomy, the Johns Hopkins University; M. T. Sudler; instructor in anatomy, Cornell University; G. Walker, instructor in surgery, the Johns Hopkins University; R. G. Whitehead, professor of anatomy, the University of North Carolina; H. M. Young, associate professor of surgery, the Johns Hopkins University. (For a description of the anatomical courses and laboratory of the Johns Hopkins University see articles by Mall, Barker, Bardeen, and Hoen, in the *Johns Hopkins Hospital Bulletin*, May–June, 1896.)

At the *University of Chicago* studies in normal anatomy are carried on in the anatomical department, the neurological department and the zoological department. In addition much of the work done in the physiological, pathological and botanical departments has bearing on anatomical problems. All of these departments have been in operation since the founding of the University in 1892. The anatomical department was at first placed in charge of Professor F. P. Mall. In 1893 Professor Mall took charge of the anatomical department of the Johns Hopkins University and anatomy at Chicago was placed in charge of A. C. Eycleshymer. The department was re-organized with L. F. Barker as professor of anatomy in 1900, when the University entered into affiliation with the Rush Medical College and established a four year course of which the first two years are given at the University. Among those who have made contributions from the anatomical laboratory in addition to Professor Barker may be mentioned R. R. Bensley, assistant professor of anatomy, the University of Chicago; A. C. Eycleshymer, professor of anatomy, University of St. Louis; J. M. Flint, professor of anatomy, the University of California; I. Hardesty, associate professor

of anatomy, the University of California; P. Kyes, assistant professor of anatomy, the University of Chicago; D. D. Lewis, J. G. Wilson and D. G. Revell, instructors in anatomy, the University of Chicago; G. E. Shambaugh; F. C. Waite, professor of histology and embryology, Western Reserve University; and R. D. Whitehead, professor of anatomy, the University of North Carolina.

The neurological department, under the direction of Professor H. H. Donaldson, is the foremost center for neurological research in the country. Among those who have made valuable contributions from his laboratory may be mentioned Elizabeth H. Dunn, S. Hatai, I. Hardesty, C. E. Ingbert, S. W. Ranson, J. R. Slonaker, and Helen Thompson. This list includes only those who have contributed several important articles.

The zoological department which has likewise been a most active center for anatomical research is treated more fully in note 32.

For the following account of anatomy at Cornell I am indebted to Prof. S. H. Gage:

At the opening of *Cornell University* in 1868 provision was made for teaching and investigation in Comparative Anatomy and Zoology. The professor at the head of the department (B. G. Wilder, appointed in 1867) also gave instruction to freshmen in all courses in physiology and hygiene. From the beginning the work in anatomy included a study of human osteology and the dissection of preserved human material (mostly still-born children) as well as the study and dissection of the lower animals. Some of Professor Wilder's earlier papers dealt with comparisons of human and animal structures and philosophical considerations in morphology and teleology. (A list of Dr. Wilder's scientific publications down to 1893 may be found in the Wilder Quarter Century Book, the first American Festschrift presented to a teacher by his pupils.)

In tracing the history of the original department four special aims seem to have been dominant: (1) to give the best possible elementary instruction to beginning students; (2) to encourage those especially interested to do advanced work and to undertake the investigation of special problems; (3) to so combine the study of human and comparative anatomy that those aiming to become physicians could most intelligently and successfully pursue their later medical studies; and (4) the establishment of independent departments with the growth of the university.

At the present time (1905) the work once included in the original department is carried on by seven independent departments as follows:

(1) the original department founded in 1868 and now designated the department of Neurology and Vertebrate Zoology. It is still under the direction of Professor Wilder. (2) The department of Entomology and Invertebrate Zoology, directed by Professor J. H. Comstock, founded in 1882. (3) The department of Histology and Embryology, under the direction of Professor S. H. Gage. This department became partly independent in 1885–86 and wholly so in 1895–96. (4) The department of Veterinary and Comparative Anatomy under the direction of Professor G. S. Hopkins, founded in 1896. (5) The department of Comparative Physiology, under the direction of Professor P. A. Fish, founded, 1896. The departments of Veterinary Anatomy and Comparative Physiology (4, 5 above) were also a part of the original chair of Veterinary Medicine founded in 1868. These two independent departments were made possible by the establishment of the New York State Veterinary College upon the Cornell Campus. (6) The department of Human Anatomy, founded in 1898 and conducted for the first two years by Dr. L. Coville and since 1900 by Professor A. T. Kerr. (7) The department of Physiology founded in 1898 in connection with the Medical College and conducted first by Dr. P. A. Fish and since 1903–4 by Professor B. F. Kingsbury. The establishment of the independent departments of human anatomy and physiology in Ithaca was made possible by the foundation of the Cornell University Medical College in New York city, and the duplication of the first two years at Ithaca.

The published work of the original department includes the numerous papers in scientific periodicals and articles in encyclopedias by Professor Wilder and S. H. Gage, and papers on anatomical and zoological subjects by W. S. Barnard, S. H. Gage, F. L. Kilborne, T. B. Stowell, Tracey E. Clark, P. A. Fish, H. W. Norris, G. S. Humphrey, Ida H. Hyde, B. F. Kingsbury, S. E. Meek, B. B. Stroud and H. D. Reed. From the department of Entomology and Invertebrate Zoology, the first independent department to bud off, have originated important books on entomology and bulletins upon economic entomology and papers on insect embryology and morphology.

In addition to the important publications from the department of Histology and Embryology by S. H. Gage papers have been published by Theobald Smith with S. H. Gage, T. B. Spence, G. S. Hopkins, Leonard Pearson, H. E. Summers, B. L. Oviatt, Susanna Phelps Gage, Edith J. Claypole, Agnes M. Claypole, B. F. Kingsbury, R. O. Moody, J. G. Needham, W. A. Hilton, W. F. Mercer, Marguerite Hempstead, Louise Katz, J. M. Berry, Isabella M. Green, Mary J. Ross, B. D. Myers, Gertrude A. Gillmore.

From the department of Veterinary and Comparative Anatomy papers have been contributed by G. S. Hopkins and M. J. Ross.

From the department of Comparative Physiology besides manuals and papers dealing with physiology and pharmacology, there are anatomical papers by P. A. Fish, A. T. Kerr, and M. T. Sudler.

From the department of Physiology, anatomical papers have been published by B. F. Kingsbury.

In New York the work done in gross anatomy falls in one department while that done in histology is under the department of pathology. The undergraduate courses include normal histology under J. S. Ferguson, embryology under I. Strauss and the histology of the nervous system under M. G. Schlapp.

In addition to papers by Dr. Ferguson and Dr. Schlapp articles on anatomical subjects have been contributed by Professor J. Ewing, head of the department of Pathology.

Both Dr. George Woolsey, Professor of Anatomy, and J. S. Haynes, Professor of Practical Anatomy, have published papers from the New York department of gross human anatomy.

Of the anatomical laboratories in medical schools which have recently exhibited scientific activity, that of J. L. Flint at the *University of California* deserves especial mention.

The passing over of the anatomical departments of our schools into the hands of men professionally devoted to the subject marks a step in advance not only from the standpoint of scientific progress but also from that of the education of the medical student. Only those who are themselves endeavoring to advance a subject can realize the progress that others are making. A mere teacher drills in the beliefs of yesterday rather than in the knowledge of today.

While the increase in scientific activity in the laboratories devoted to the anatomical sciences in the various institutions is certainly encouraging it is still far from what it should be. Probably 500 individuals are engaged in teaching anatomy in the 166 medical schools of the country and it may be estimated that probably over $500,000 a year is expended for the various anatomical courses maintained. In less than twenty-five institutions is scientific research seriously attempted in the anatomical departments of the medical schools. Among these may be mentioned the University of California, Chicago (Rush), Columbia, Cornell, Harvard, Indiana, the Johns Hopkins, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Pennsylvania, St. Louis, and Texas.

(b) *Nature of Instruction.*

The nature of the instruction in human anatomy given in this country has been thus recently summed up by F. P. Mall:

"It is possible to classify the teaching of anatomy in America under four heads.

"The first and lowest order is found in those schools which give a course of crude lectures on anatomy with a dissecting-room in which the work is not directed, but is done in a superficial way. Often the students do not dissect at all. At best they use a brief guide or a quiz compend which enables the student to 'learn enough' to pass the examinations.

"The teaching of anatomy is of a higher order when it follows closely some text-book, especially Gray, when it has lectures and recitations and enough work in the dissecting-room to enable the student to identify the grosser structures, thereby giving enough information to enable the student to pass State examinations. Most of the medical students desire courses of this order.

"In a third and higher order of medical school, about twenty or which may be counted, the course is given to aid the student in their subsequent medical studies. Practical things are pointed out in lectures, and emphasized again in the dissecting-room, and finally the student is examined upon them. Both students and teachers work pretty hard, and at the end of the course all feel that much good has been done.

"In the fourth order of anatomical course it is considered that there are others to be satisfied besides the teachers in a few practical branches—there are teachers in the other sciences, physiology, neurology, pathology, as well as anatomy itself. A student told me recently that he had been studying one thing to help him in another all of his life, and he was dead tired of it; he now desired to study things that were worth studying for their own sake. For him anatomy could not be considered an ancillary science. In presenting a science to students no attitude can be defended, except that in which the science is studied for its own sake. In so doing the development of the student cannot possibly be ignored, for understanding and self-development go hand in hand." (J. H. U. Hospital Bulletin, vol. XVI, No. 167, February, 1905.)

(c) *Expenses.*

Comparatively few educational institutions publish detailed accounts of income and expenditure. It is unfortunate that the policy of secrecy is so prevalent in their financial administration. Those universities which like Harvard and Columbia publish full statements of receipts and expenditures certainly seem to gain the confidence of those wealthy members of the community who desire to aid educational advancement. The State universities likewise publish more or less full accounts of receipts and expenditures but as a rule in so cumbersome a form that it is difficult to gain insight into expenditures for specific purposes.

In thirty-six medical schools about $250,000 a year is spent on gross and microscopic anatomy and on histology. It seems quite probable that the other 130 schools spend an equal sum, if not much more, upon that subject.

At the *Harvard Medical School* there is a department of "anatomy" with a professor, an assistant professor, a demonstrator and seven assistant demonstrators, and a department of histology and embryology with a professor, two instructors and three assistants. In addition there is a curator of the anatomical museum. Although no specific itemized salary list is published (for the whole medical school the salaries for instructors amounted in 1902–3 to $102,091.66) it is safe to estimate the amount paid for salaries for anatomical instruction at about $20,000. Two special janitors and a technician are employed at a cost of not much less than $2,000. The appropriations for the year 1902–3 for laboratory supplies and apparatus were for "anatomy" $2,750.00, histology and embryology $1,186.45, and for the museum $312.00. For some of the other departments they were as follows: chemistry, $1,232.39; physiology, $4,307.41; pathology, $800.00. The accounts of the various laboratories of the scientific departments at Cambridge are not published in such form that comparison with the figures of the anatomical department is made easy. The payments for the Museum of Comparative Zoology were $42,082.36. In addition appropriations were made for the zoological department.

At *Columbia University* for the year 1902–3 in the anatomical department (human and comparative vertebrate anatomy) the salaries of the instructional force (a professor, a demonstrator and eight assistant demonstrators) amounted to $18,281.25. For supplies $3,292.12 was granted and for special service (a technician, an artist and three janitors) $3,240.00. Histology is there given in the pathological depart-

ment for which the following appropriations were made: salaries, $28,094.40; supplies, $2,392.76; apparatus, $197.57. For physiology the following sums were allowed: salaries, $13,099.99; supplies, $950.54; laboratory equipment, $455.93; table at Woods Hole, $100.00. In the zoological department of the University $16,450.60 was allowed for salaries, $1,199.66 for apparatus, and $78.33 for special purposes. In the botanical department $8,324.96 was given for salaries and $599.54 for supplies.

At *Chicago University* although no detailed account of expenditures is published the departments devoted to the anatomical sciences are run on a scale at least fully as liberal as those at Harvard and Columbia. There are in the department of anatomy a professor, two assistant professors and seven instructors and assistants; in the department of neurology a professor and two associates and an assistant; and in the department of embryology an associate professor and one or more instructors. In these laboratories an artist and several technicians and special janitors are employed. The total running expenses probably amount to over $40,000.

The *Johns Hopkins University* publishes no account of its yearly expenditures. There are on the teaching staff of the department of anatomy (gross human anatomy, histology and embryology) a professor, two associate professors, an associate, two instructors and several assistants. The total amount paid for salaries is a little over $12,000. A technician and two janitors are employed in addition to an engineer and occasional extra service. For these the salaries must amount to $2,000. Four thousand dollars may be counted for laboratory expenses. Thus the total yearly expenditures at this university amount to nearly $20,000.

Cornell University offers instruction in anatomy both at Ithaca, N. Y., and in New York city. At Ithaca there is a professor of neurology, one of histology and embryology and one of anatomy, and in addition there are (1904-5) eleven instructors and assistants in the various laboratories devoted to the above subjects. At New York there are two professors and an instructor in anatomy, two instructors in histology, and one in embryology, and eleven demonstrators and assistants in anatomy and histology. The total cost of running these various departments must be considerably over $25,000. At New York histology is given in the department of pathology.

At the *endowed universities* in which the most scientific research is carried on, the yearly expenses in the departments devoted to anatomy in the medical school may be said to range from $20,000 to $40,000. In the leading medical schools of the State universities less is spent

on anatomy but in them research is confined in the main to the hard working members of the teaching staff.

At the medical school of the *University of Minnesota* anatomy is taught in two separate but co-ordinated departments, that of "anatomy" and that of "histology and embryology." In the former there are a professor, a demonstrator and a prosector. For the year 1901–2 the salaries of the staff of instruction amounted to $3,300 and the appropriations for the laboratory to $3,070.14. In the department of embryology and histology there are a professor, an assistant professor, an instructor and an assistant. In 1902 the salaries of the staff of instruction amounted to $5,256.27 and the appropriation for the laboratory to $2,490.49. A special janitor and part of the services of a carpenter and a mechanic are at the disposal of the two departments. If $1,500 be counted for service, the total amount appropriated for anatomy at this university, exclusive of heat, light, etc., amounted in 1901–2 to over $15,000. In addition courses in comparative anatomy and histology are given in the biological department. The appropriations for this and various other departments of the University for the year 1901–2 were as follows: Botany: salaries $4,690, bills $4,175.37; biology: salaries, $5,185, bills, $911.14; physiology: salaries $3,476.26, bills $2,384.20.

At the *University of Michigan* there are two co-ordinate departments, one of "anatomy" and one of "histology and embryology." In the former there are a professor, two instructors and four student assistants; for the latter a professor and an instructor. A specific list of the salaries paid is not published. They amount to about $10,000. For the year 1902–3 $2,224.86 was allowed for the laboratory expenses of the anatomical department and $1,221.06 for those of the department of histology. With the exception of the janitor of the anatomical department no trained technicians are employed. The total yearly expenditure for the laboratories is somewhat less than $15,000.

At the medical school of the *University of California* in the anatomical department there are a professor, an assistant professor, an instructor and four student assistants. The salaries of the instructional force amount to $6,650 and $2,500 is allowed for laboratory expenses. A skilled technician and a special janitor are employed the salaries of whom amount to $1,300. The total running expenses amount to about $10,500. For these data I am indebted to Professor Flint. President Wheeler kindly permitted their publication.

In the medical departments of those *State Universities* in which the most scientific work in anatomy is done the total yearly expenditures amount to between $10,000 and $15,000.

On comparing the table of the appropriations allotted to the anatomical laboratories of the most liberally treated American institutions with the corresponding figures given in note 10 for the German institutions it may be seen that in general the allotments in America are less. As to salaries it is probable that the German professors of anatomy are better paid than the American, while the American instructors and associates in the better institutions are better paid than the German dozents.

(d) *Salaries.*

For 502 "ordenliche Professoren" in the Prussian Universities for the year 1900 the average income from salaries and fees was 11,735 M. Of these thirty had less than 6,000 M., seven between 30,000 and 40,000 M. and three over 40,000 M. (Die Universitaten im deutschen Reich, W. Lexis, 1904.) The professors of anatomy are among those who receive the highest income. One German professor is said to receive over $10,000 a year from his courses in anatomy. In America the highest salary paid to a professor of anatomy is, I believe, $7,500. There are three men who receive over $5,000 and about the same number who receive $4,000 to $5,000, perhaps six who receive $3,000 and as many who receive between $2,000 and $3,000. Several others receive $2,000 or less. The great majority receive small salaries and depend on the practice of medicine for a living. The highest salaries are paid in endowed institutions. Assistant and associate professors in the richer endowed institutions receive from $1,500 to $2,500 and in the more liberal State institutions from $1,000 to $2,000 according to length of service. Instructors and associates receive as a rule from $800 to $1,500 when they devote all their time to teaching and research. Assistants seldom receive more than $600. In America the professors and instructors in the medical schools who devote all their time to administration, teaching and research are paid about the same salaries which are paid to those holding corresponding positions in other departments of the universities. Their income is very much less than the more successful men who practice medicine.

(e) *Buildings.*

In respect to laboratories the anatomical departments of the German universities have as a rule a decided advantage over the American. The Harvard Medical School will soon have a splendid building especially designed for the subject. Associated with the University of

Pennsylvania is the Wistar Institute, a fine building designed for the beautiful Wistar anatomical museum and for research, but the building can not be used for undergraduate teaching. In the University laboratories the quarters devoted to human dissection have been inadequate. It is to be hoped that the immense building recently built there for laboratories for the medical department will now permit much more adequate quarters to be arranged for the student work in anatomy. At the Johns Hopkins University an unpretentious but convenient building is devoted to the anatomical department. (See F. Mall, Bull. Johns Hopkins Hospital, 1896.) The University of Chicago has a special building for anatomy. At Columbia University, Cornell University, the University of Michigan, Syracuse University, the University of California and the University of Missouri quarters designed especially for scientific anatomy have been placed in large laboratories devoted to the medical sciences. At the Universities of Iowa and Minnesota there are special buildings for human anatomy while histology and embryology are quartered in another building devoted to the medical sciences. In some other institutions more or less commodious quarters are given to gross and microscopic anatomy but in general anatomy in the American medical schools is far from being adequately housed. In the better institutions from 12,000 to 50,000 square feet of floor space are given up to the anatomical laboratories.

Professor Flint (Bull. Johns Hopkins Hospital, Feb. 1905, p. 33) has described the alteration of an old fashioned dissecting-room into modern quarters for scientific anatomy as follows:

"The large dissecting-room was provided with roof light, a tarred floor and rough brick walls. In the conversion of this space to more modern dissecting-rooms several points concerning anatomy in this country had to be born in mind. In the first place anatomical material was often poorly preserved and frequently scant in quantity; in the second, by tradition, students who crossed the threshold of a dissecting-room assumed at times that they were absolved from all standards of good conduct. Hats were worn; students dressed in out-landish costumes. Smoking was generally permitted, and boisterous conduct accompanied by the throwing of material, were not infrequent occurrences. To break this tradition and to obtain in a measure the morale and seriousness characteristic of the students in other departments of the university, we profited by the experience of Professor Mall of the Johns Hopkins University, who, in the construction of his laboratory, went on the assumption that students should be divided into small groups and should be provided with dissecting-rooms, which resemble a modern laboratory more than they do a stable. Accord-

ingly, the large dissecting-room was re-covered with a new floor, and was cut up into a series of small rooms, each with a capacity of from 1 to 4 tables, thus segregating small groups of students. In this way fewer distractions occur and one obviates the inevitable noise that occurs when large bodies of even well behaved students are quartered in the same laboratory. The rooms, moreover, were fitted with especial care to make them clean, neat, and attractive, hoping in this way to obtain the effect of a pleasant environment upon the work of the students during the period of dissection. The large room was 35 by 100 feet, and was subdivided into eight small dissecting-rooms, a research room and a museum. The largest of these small dissecting-rooms is 20 by 21 feet, with a comfortable capacity of four tables and a maximum of six, while the smallest is 12½ by 15 feet, and holds one dissecting table conveniently. The remainder are so arranged as to hold from one to three tables. The rooms are provided with heavy tables with zinc tops, draining toward the center into a bucket suspended beneath the table. Adjustable arm-rests and book-stands also form part of the equipment. As soon as the body is cut in parts, students are no longer forced to work together, and in consequence one or two small tables with book-stands are provided in each dissecting-room. There is a sink with running-water and a large drip-board to hold parts while they are being moistened, or for the study of the viscera. Each room has, besides, an articulated skeleton for convenient reference and a blackboard upon which schemata may be drawn and relations studied. During the period of dissection the student is held responsible for his material, which must be carefully wrapped in cheese-cloth at the close of each laboratory period. These wrappings are moistened in a solution of carbonic acid, glycerine and water, made according to the following formula:

Water	1000cc.
Glycerine	30cc.
Carbonic acid	20cc.

"This procedure prevents desiccation and, at the same time, acts to a certain extent as a preservative."

In many of the leading institutions anatomical material is preserved in cold storage plants. Recently improved methods of embalming have, however, rendered these unnecessary except where large numbers of bodies must be cared for.

(f) *Length of Courses.*

The proportional amount of time devoted to human gross anatomy, histology and embryology varies greatly in different institutions. In 41 colleges the total amount of scheduled time devoted to medical studies during the four years' course averaged 4095 hours in 1902–3, the total amount of time devoted to human anatomy 549, and to histology and embryology 219. The standard proposed to the American Medical Association by the committee appointed to study the subject is 3600 hours for the course, 500 hours for anatomy and 200 hours for histology and embryology. The anatomical studies therefore constitute about a fifth of the medical curriculum proposed for American schools. (See Jrl. Am. Med. Assn., Aug. 15, 1903; and N. Y. Med. Jrl., July, 1904.)

23, (p. 99). CONTRIBUTIONS FROM PHYSIOLOGICAL AND PATHOLOGICAL LABORATORIES.

Among the important contributions to anatomy made in this country from physiological laboratories may be mentioned the work of Howell on the blood, of Howell and Huber on the regeneration of nerves, and the extensive studies of Loeb and his pupils in experimental morphology. From the pathological laboratories the work of F. P. Mall on reticulum and on the blood vessels of the stomach, of Berkley on nerve endings in various tissues, of Mallery on stains and on the connective tissues, of Adolph Meyer on nerve cells, of E. L. Opie and R. M. Pearce on the pancreas, W. G. MacCallum on the lymphatics, and Warthin on the haemolymph glands may especially be mentioned. A list of the numerous publications by clinicians on anatomical subjects would be too long for citation here. The work of Osler on the blood-plates, of Williams on the female reproductive organs, of Clark on the ovary and corpus luteum, of H. Cushing and Allen Starr on the nervous system, may, however, be mentioned.

24, (p. 99). DEVELOPMENT OF BIOLOGY IN AMERICA.

For the history of the development of the biological sciences in this country see:

A. S. Packard: "A Century's Progress in American Zoology," American Naturalist, Vol. 10, 1876.

G. Brown Goode: 'Beginnings of American Science," Proceedings Biological Society, Washington, III, 1884–6, and IV, 1886–8.

J. P. Campbell: "Biological Teaching in the Colleges of the United States," U. S. Bureau of Education, Circular of Information, No. 9, 1891.

The letters of L. Agassiz ("L. Agassiz, his life and correspondence,") edited by his wife, throw interesting light on zoology in America at the period when Agassiz arrived here and during his life in this country.

25, (p. 100). JEFFRIES WYMAN AND THE HERSEY PROFESSORSHIP.

In 1847 the Hersey professorship of anatomy was transferred from the Harvard Medical School in Boston to the newly established Lawrence Scientific School at Cambridge. O. W. Holmes was appointed to the newly established Parkman professorship of anatomy and physiology in the Medical School. At Cambridge Wyman had small classes in comparative, including human anatomy, and produced much scientific work of sterling value. Wyman died in 1874. Asa Gray delivered an interesting and sympathetic memorial address before the Boston Society of Natural History. (Vide Gray's Collected Works, and the Proceedings of the Boston Society of Natural History, Oct. 7, 1874.)

The Hersey professorship of anatomy was established from the bequest of Ezekiel Hersey of Hingham who died in 1770 leaving 1000 pounds and of his widow who left a like sum to be applied to the support of a professor of anatomy and surgery at Harvard. (Thatcher, Medical Biographies, 1828.) Dr. Abram Henry and Dr. John Cumming also each gave 500 pounds for the same purpose. This was the first endowed professorship of anatomy in America. Seldom has money been left to better purpose. John Warren, John Collins Warren, J. Wyman and E. L. Mark, who have successively held the chair have been among the foremost in the development of the anatomical sciences in America. The Parkman professorship of Anatomy was established at the Harvard Medical School in 1847 in honor of George Parkman who gave a large tract of land to the school. Recently James Stillman has given $100,000 for the establishment of a professorship of comparative anatomy at the Medical School. It would be well were similar endowed professorships in anatomy established in connection with other universities.

26, (p. 100). AGASSIZ.

The brilliant American career of Agassiz, who became professor of zoology in the Lawrence Scientific School at its establishment in 1847, is too well known to be treated here at length. He awakened great popular interest in biology in a country where there had previously been but little and did more perhaps than any other one individual to sow the seeds of the fruitful zoology which has grown up since his death in 1873. He introduced the study of comparative embryology into this country and excited fresh interest in paleontology and the broader relationship existing between living organisms. Agassiz's interest however, was rather in structure as a basis of systematic classification than in the intrinsic structure of organisms or in structure in relation to function. In the American Naturalist for 1898 may be found a list of the chief pupils of Agassiz.

27, (p. 100). CONTRIBUTIONS FROM THE ZOOLOGICAL LABORATORY OF HARVARD COLLEGE UNDER THE CHARGE OF E. L. MARK.

Among the contributors to anatomy may be mentioned:

Howard Ayres; M. A. Bigelow, adjunct professor of biology, Teachers College, Columbia; R. P. Bigelow, instructor in biology, Massachusetts Institute of Technology; Mary A. Bowers, instructor in zoology, Wellesley College, Wellesley, Mass.; W. E. Castle, assistant professor of zoology, Harvard University; C. B. Davenport, director Carnegie Laboratory, Cold Spring Harbor, Long Island, N. Y.; Gertrude C. Davenport; C. R. Eastman, assistant in vertebrate paleontology, Museum of Comparative Zoology, Harvard University; C. H. Eigenmann, professor of zoology, University of Indiana; H. H. Field, director of concilium bibliographicum, Zurick, Switzerland; R. W. Hall, instructor in zoology and biology, Lehigh University, South Bethlehem, Pa.; J. I. Hamaker, professor of geology and biology, Trinity College, Durham, N. C.; Ida H. Hyde, associate professor of physiology, University of Kansas, Lawrence, Kas.; H. S. Jennings, associate professor of zoology, University of Pennsylvania; C. A. Kofoid, associate professor of histology and embryology, University of California; T. G. Lee, professor fessor of histology and embryology, University of Minnesota; F. T. Lewis, instructor in embryology and histology, Harvard Medical School; W. A. Locy, professor of zoology, Northwestern University; W. J. Moenkhaus, assistant professor of physiology, Indiana Univer-

sity; H. V. Neal, professor of biology, Knox College, Galesburg, Ill.; Margaret L. Nickerson, instructor in histology and embryology, University of Minnesota; W. S. Nickerson, associate professor of histology and embryology, University of Minnesota; Herbert Osborn, professor of zoology and entomology, Ohio State University; G. H. Parker, associate professor of zoolgy, Harvard University; W. Patten, professor of zoology, Dartmouth College; Julia B. Platt; C. W. Prentiss, instructor in biology, Western Reserve University; H. W. Rand, instructor in zoology, Harvard University; J. E. Reighard, professor of zoology, University of Michigan; W. E. Ritter, professor of zoology, University of California; Porter E. Sargent, Cambridge, Mass.; F. Smith, University of Illinois; R. M. Strong, instructor in zoology, University of Chicago; W. L. Tower, associate in embryology, University of Chicago; F. C. Waite, assistant professor of histology and embryology, Western Reserve University; H. B. Ward, professor of zoology, University of Nebraska; A. W. Weyse, instructor in zoology, Massachusetts Institute of Technology; C. O. Whitman, professor of zoology, University of Chicago; W. A. Willard, adjunct professor of zoology, University of Nebraska; S. R. Williams, professor of biology, Miami University, Oxford, Ohio; W. M. Woodward, keeper of the Museum of Comparative Zoology, Cambridge, Mass.

28, (p. 100). SCHOOLS OF ANATOMY AT BROWN AND CORNELL.

Under the stimulus of Professor Packard, Brown built up a strong productive department of zoology and anatomy. In 1890 H. C. Bumpus was added to the staff and from 1891–1902 was professor of comparative anatomy. In 1902 Professor Bumpus became director of the American Museum of natural history, New York. At present A. D. Mead is professor of comparative anatomy, F. P. Gorham is associate professor of biology, and F. T. Fulton instructor in pathology and histology. Human anatomy has been taught there since 1902.

An appreciative account of Professor Packard's life work may be found in *Science*, March 17, 1905.

The development of anatomy at Cornell under Professor Wilder has been treated of in note 22.

29, (p. 100). YALE.

At Yale, B. Silliman, professor of chemistry, mineralogy and geology, from 1802 to 1864, though no anatomist, did much to arouse in-

terest in natural science. J. D. Dana, professor of geology and mineralogy from 1850 to 1895, was a good zoologist, as well as a great geologist. A. E. Verrill has been professor of zoology since 1864, and S. I. Smith professor of comparative anatomy since 1875. O. C. Marsh, who was appointed professor of paleontology in 1866, made many contributions to this subject.

30, (p. 100). PRINCETON.

At Princeton an active scientific atmosphere was introduced by Arnold Guyot, Agassiz's friend, professor of geology from 1854 to 1884. This was furthered by the establishment of the John C. Green School of Science in 1873. Professors Scott, Osborn and McClure have done much there to develop comparative anatomy.

Among those who have contributed to anatomy at Princeton may be mentioned G. Macloskie, professor of biology since 1882; W. B. Scott, professor of geology since 1882; H. F. Osborn, professor of comparative anatomy from 1882 to 1892; C. T. W. McClure, instructor and professor of comparative anatomy since 1893; W. M. Rankin, instructor and professor of invertebrate zoology since 1892; and U. Dahlgren, instructor in histology since 1896. Professor Scott has established an unusually good paleontological museum, and Professor McClure one of the best museums of comparative anatomy in the country.

31, (p. 100). PENNSYLVANIA.

Philadelphia since the time of Franklin has been an active center for research. The University, however, did little for scientific anatomy, in spite of the activities of men like Horner, Leidy and Harrison Allen, until 1873, when a laboratory for comparative anatomy was established. (See "Benj. Franklin and the Univ. of Penn.," F. N. Thorpe, U. S. Bureau of Ed., Circ. of Inf., 1892, No. 2.) In 1884, owing to the generosity of H. Jayne and the support of the provost, W. Pepper, the School of Biology was established. In 1889 this became the department of Biology. Under the leadership of such men as Leidy, Cope, Ryder, and Conklin, the work done here has gone far to further the advance of anatomy, as well as other aspects of biology in this country.

The professors in the biological department at Pennsylvania have been, in comparative anatomy, A. J. Parker, from 1880 to 1890, H. Allen, from 1891 to 1895, E. D. Cope, 1886–1897; in invertebrate morphology, B. Sharp, from 1884 to 1886; in physiology, N. G. Randolph, from 1883 to 1886, H. A. Hare, from 1887 to 1890, E. Reichert, since

1890; in biology, H. Jayne, from 1883 to 1884, C. S. Dolle, from 1885 to 1888, M. J. Greenman, 1887; mammalian anatomy, C. M. Burk, 1887–1897, E. A. Kelly, from 1887 to 1889; zoology, E. G. Conklin, since 1899; comparative embryology, J. A. Ryder, from 1886 to 1895, E. G. Conklin, from 1895 to 1899. H. S. Jennings is assistant professor of zoology and J. P. Moore and P. P. Calvert are instructors in zoology. T. H. Montgomery, now professor of zoology at the University of Texas, was assistant professor of zoology, from 1900 to 1903. Among others who have made contributions from the laboratory may be mentioned: H. Heath, H. Crawley, J. R. Murlin, D. B. Casteel, E. F. Phillips, J. L. McClendon, Louise Nichols, Caroline Thompson, Louise B. Wallace, J. A. Nelson, R. C. Schmidt and H. Fox.

32, (p. 100). THE JOHNS HOPKINS.

In 1876 the Johns Hopkins University was opened with H. Newell Martin as professor of biology and W. K. Brooks as fellow. While Martin developed an active graduate school for the training of vertebrate physiologists, Brooks paid particular attention to the biology of invertebrates. He organized the Chesapeake Zoological Laboratory, which was established for several successive summers at different places along the Atlantic coast and did much to further the study of the anatomy and development of the marine fauna of the region.

Among the biologists who studied at the Johns Hopkins University may be mentioned J. P. MacMurrich, professor of zoology, Haverford, from 1886 to 1889, professor of anatomy at Michigan since 1893; S. F. Clarke, professor of zoology at Williams since 1881; W. T. Sedgwich, professor of biology at the Massachusetts Institute of Technology since 1884; E. B. Wilson, professor of zoology at Bryn Mawr from 1885 to 1891, and at Columbia since 1891; C. O. Whitman, director Allis Lake Laboratory, from 1886 to 1889, and professor at Chicago since 1892; H. H. Donaldson, professor of neurology at Chicago since 1892; H. F. Nachtrieb, professor of zoology at Minnesota since 1885; H. L. Osborn, professor at Purdue from 1884 to 1887, professor of biology and geology at Hamlin University, St. Paul; F. H. Herrich, professor of biology at Western Reserve University since 1881; A. B. Macallum, professor of physiology at Toronto since 1886; H. V. Wilson, professor of biology at the University of North Carolina since 1888; T. H. Morgan, professor of biology, Bryn Mawr from 1891 to 1904, professor at Columbia, 1904; E. G. Conklin, professor of zoology, Northwestern University from 1891 to 1895, professor of zoology, University of Pennsylvania since

1895; R. G. Harrison, associate professor of anatomy, Johns Hopkins University since 1895; G. Lefevre, professor of zoology, University of Missouri since 1898; C. P. Sigerfoos, assistant professor of zoology, University of Minnesota since 1897; G. A. Drew, professor of biology, University of Maine since 1900; C. W. Greene, professor of physiology, University of Missouri since 1900; C. Grave, associate in zoology, Johns Hopkins University; J. E. Duerden; A. M. Reese, associate professor of histology, Syracuse University; W. C. Curtis, assistant professor of zoology, University of Missouri and G. L. Houser, professor of animal morphology, Iowa University.

33, (p. 100). RECENT DEVELOPMENT OF BIOLOGY.

"In all of the 400 colleges and universities, with a dozen conspicuous exceptions, the instruction in the biological sciences is little more than a farce. The teachers of biology are mostly men without biological training, men whose ideas and methods are those of a generation ago, and who have no more idea of modern science and scientific thought than have the poorest pupils who are unfortunate enough to come under them"; wrote the editor of the American Naturalist in 1887.

In 1891 out of the 111 colleges and universities in but 41 were the biological departments in the hands of men devoted to teaching that subject only; there were but five laboratories built especially for biology, only five or six institutions where advanced experimental work could be performed and only three or four in which provision was made for the study of vegetable physiology. (See J. B. Campbell, U. S. Bureau of Education, Circular of Information, 1891.)

Early in the nineties a notable impetus to the advance of biology was given by the establishment of several liberally endowed universities the direction of which fell into the hands of men in sympathy with scientific research.

At *Columbia* in 1890 N. L. Britton was appointed professor of botany, and in 1896, L. M. Underwood. In 1891 H. F. Osborn and E. B. Wilson were appointed professors of zoology. From 1811 until 1890 Columbia had no professor of natural history, botany or zoology. Under the leadership of Professors Wilson and Osborn, Britton and Underwood, Columbia has developed into one of the strongest departments of biology in the world, and from there many important contributions to anatomy have been made. Bashford Dean was made adjunct professor of zoology in 1896, H. E. Crampton, G. N. Calkins,

M. A. Bigelow in 1903. In 1904 T. H. Morgan was made professor of experimental zoology. Among others in the collegiate department who have contributed more especially to anatomy may be mentioned J. H. McGregor, instructor in zoology, and O. S. Strong, tutor in comparative neurology. In addition to the work of these men important contributions have been made by B. A. Bensley, L. I. Dublin, B. B. Griffin, N. R. Harrington, C. J. Herrick, professor of biology, Denison University, Granville, Ohio, W. E. Kellicott, R. S. Lull, A. P. Mathews, assistant professor of physiological chemistry, University of Chicago, F. B. Summer, instructor in natural history, College of the City of New York, W. S. Sutton, J. C. Toner, N. Yatsu, and Charles Zeleny, instructor in zoology, the University of Indiana.

At *Clark University*, organized at Worcester in 1889, the President, G. Stanley Hall, got together a remarkable number of productive biologists, among whom may be mentioned G. Baur, F. Boas, H. C. Bumpus, H. H. Donaldson, C. L. Edwards, A. C. Eysleshymer, C. F. Hodge, E. O. Jordan, F. R. Lillie, W. P. Lombard, F. P. Mall, W. S. Miller and W. M. Wheeler. After three years of scientific activity the laboratory was disorganized by the departure of the greater part of the men mentioned to the university newly organized at Chicago. Since 1892 Chicago has had one of the most productive biological departments in the country.

The original staff at the *University of Chicago* consisted of C. O. Whitman, professor of biology and animal morphology; F. P. Mall, professor of anatomy; H. H. Donaldson, professor of neurology; J. Loeb, assistant professor of physiolgy; G. Baur, assistant professor of paleontology; W. M. Wheeler, instructor in biology; A. D. Mead, fellow in biology; A. C. Eycleshymer, assistant in animal morphology; and F. R. Lillie, fellow in morphology. Mall became professor of anatomy at the Johns Hopkins University; Wheeler, professor of zoology at the University of Texas and later curator of invertebrate zoology at the American Museum, New York; A. D. Mead, associate professor of embryology and neurology, then professor of comparative anatomy at Brown; A. C. Eycleshymer, professor of anatomy at the University of St. Louis. C. B. Davenport became assistant professor of zoology at Chicago in 1899. In 1904 he assumed charge of the Carnegie laboratory at Cold Spring Harbor. At present the work in anatomy in the laboratory is done under the direction of Professor Whitman and of F. R. Lillie, associate professor of embryology. Among those who have worked on anatomical problems in the zoological department at Chicago in addition to those named above may be mentioned B. M. Allen, instructor in anatomy, the University of Wisconsin; W. J. Baum-

garten, instructor in zoology, the University of Kansas; C. M. Child, instructor in zoology, the University of Chicago; C. M. Clapp, professor of zoology, Mt. Holyoke College, S. Hadley, Mass; Agnes M. Claypole; E. R. Downing, professor of biology, Michigan Northern State Normal School; M. F. Guyer, professor of zoology, University of Cincinnati; E. H. Harper, instructor in zoology, Northwestern University, Evanston; O. P. Hay, curator, American Museum of Natural History; S. J. Holmes, instructor in zoology, University of Michigan; G. W. Hunter, Jr.; E. Kirk, assistant in anatomy, Chicago; Henry Lane; R. S. Lillie, instructor in physiology, University of Nebraska; W. A. Locy, professor of zoology, Northwestern University; W. J. Moenkhaus, assistant professor of physiology, the University of Indiana; J. Scott and R. M. Strong, instructors in zoology, and L. T. Tower, instructor in embryology, the University of Chicago; A. L. Treadwell, professor of biology, Vassar College, Poughkeepsie, N. Y.; S. Watase, professor of cellular biology, the University of Tokio; W. Zelleny, instructor in zoology, the University of Indiana. (See University of Chicago Decennial Publications, First Series, Vol. I, President's Report.)

Although the establishment of active, scientifically productive biological departments at Columbia and the University of Chicago mark the chief recent events in the progress of anatomical research, from the biological standpoint, there has been an impulse in the same direction in many other colleges and universities. In addition to the zoological departments of these two institutions and the leading departments in the older institutions such as those of Harvard, the Johns Hopkins, Pennsylvania, Princeton, Cornell and Brown, there may be mentioned the departments at Alma College, Michigan, under B. N. Harper; Bryn Mawr, successively under E. B. Wilson, and T. H. Morgan; California under W. E. Ritter; Dartmouth under W. Patten; Cincinnati under M. F. Guyer; Denison University, Granville, Ohio, under C. H. and C. J. Herrick; the University of Indiana under C. H. Eigenmann and W. J. Moenkhaus; the University of Iowa under G. L. Houser; the University of Kansas under S. W. Williston, Ida H. Hyde and C. E. McClung; Knox College, Galesburg, Ill., under H. V. Neal; Leland Stanford, Jr., University, under O. P. Jenkins and F. M. McFarland; the University of Maine, Orono, under G. Drew; the University of Michigan under J. E. Reighart and H. O. Jennings; the University of Minnesota under H. F. Nachtrieb and G. E. Sigerfoos; the University of Missouri under G. Lefevre and W. C. Curtis; Mt. Holyoke under C. M. Clapp; Nebraska successively under J. S. Kingsley and H. B Ward; the University of North Carolina under H. V. Wilson; Northwestern University under W. A. Locy; Ohio Wesleyan, Delaware, Ohio,

under E. L. Rice; Smith College, Northampton, under H. H. Wilder; Syracuse University under C. W. Hargitt; Texas successively under W. M. Wheeler and T. H. Montgomery; Trinity College, Hartford, under C. L. Edwards; Tufts College, under J. S. Kingsley; Vassar College, Poughkeepsie, under A. L. Treadwell; the University of West Virginia, under J. B. Johnston; Western Reserve University, Cleveland, Ohio, under F. H. Herrick; Williams College under S. F. Clarke, J. J. Peck and J. L. Kellogg; the University of Wisconsin under E. A. Birge, W. S. Marshall and W. S. Miller; and the Woman's College, Baltimore, under M. M. Metcalf and F. Peebles. In a number of other institutions there has been considerable activity in lines of research other than the morphological. In perhaps 20 per cent of the colleges and universities of the country some scientific investigation in biology is carried on.

In almost all of these institutions, however, there is still far too much routine teaching done by the members of the staff. Agassiz prided himself on teaching men to observe. His educational children and grandchildren spend too much time in telling pupils what to know. Research is carried on chiefly during vacations and too often without intelligent support from those in whose hands the direction of the institution lies. Little training in investigation can under these circumstances be given to others, and what scientific work is done is mainly by instructors who have elsewhere received their training. There are some exceptions. Among these are Bryn Mawr College, where, under E. B. Wilson and then under T. H. Morgan, there was developed a laboratory wonderfully productive in the field of experimental morphology, the state universities of Michigan, Nebraska, Indiana and Wisconsin, and Denison University, Granville, Ohio.

The study of *vegetable anatomy* was taken up in a scientific spirit later than animal morphology and has received less extensive study. Among universities in the biological departments of which it has received special attention may be mentioned Harvard, under the direction of W. G. Farlow, and R. Thaxter, Columbia under L. M. Underwood, Nebraska under C. E. Bessey, Leland Stanford under D. H. Campbell, the University of California under W. A. Setchell, the Johns Hopkins under D. S. Johnson, the University of Indiana under S. M. Mottier, and the University of Wisconsin under R. A. Harper.

Biological laboratories well adapted for work, though often overcrowded, may be found at the following, among other institutions: Bryn Mawr, Brown, Cornell, Harvard, the Johns Hopkins University, Leland Stanford, Michigan, Minnesota, Pennsylvania, Princeton, Trinity College, Hartford, Vassar College, Western Reserve University, and

Williams. In most institutions the biological laboratories still occupy ill adapted quarters in some building devoted to many other purposes.

34, (p. 100). RELATIONS OF UNIVERSITY BIOLOGICAL DEPARTMENTS TO MEDICAL SCHOOLS.

At the time of the establishment of a graded curriculum in the medical schools the better colleges offered good practical laboratory courses in general biology (see Note 18). Students who had taken the work were found often to succeed better in medicine than those who had not. In many medical schools they were given advanced standing. With the increase of standards of admission to the better schools a certain amount of preliminary training in biology was required. In addition to this required amount of work many universities, like Wisconsin, offered in their biological departments opportunity for some of the work covered by the first two years of the medical curriculum. At Harvard in the fifties, at Cornell in the seventies, some opportunity for the dissection of human bodies was offered. In 1890 the University of North Carolina offered the first year of the medical curriculum in its collegiate department and a few years later the first two years of a four years course, the last two years being given at Raleigh. The University of Kansas offered in 1894–5 a course covering the first years work of the medical curriculum of a good medical school and in 1898–99 the work of the first two years was offered. In 1898 Cornell offered at Ithaca, N. Y., the full first two years of a medical curriculum. In its medical department at New York a complete four year course is offered. In 1900 the University of Chicago entered into an agreement with the Rush Medical College whereby the courses in biological sciences, in chemistry and in physics, requisite for a medical training, were to be given at the University, while the clinical branches were to be taught as heretofore at the Medical College. In 1902 the University of Nebraska adopted a policy similar to that of Cornell, mentioned above. In 1902 the University of West Virginia, and in 1903 the Universities of Indiana and Mississippi offered work covering the first two years of a medical curriculum. Brown University, Providence, Rhode Island, likewise offers much of the work commonly covered in this curriculum, although no attempt is there made to forestall the work of the medical school.

35, (p. 101). SEA SIDE AND LAKE LABORATORIES.

The establishment of laboratories at the sea side and lake shore for the purpose of furnishing facilities for biological study and investigation, either during the summer or throughout the year, began when John Anderson presented Agassiz with Penikese Island and $50,000 as an endowment for a laboratory. At Agassiz's death in 1873 this laboratory was discontinued. Alexander Agassiz established a private laboratory at Newport, R. I., soon afterwards, and has extended its facilities to a number of workers. In 1881 the Boston Society of Natural History had a laboratory at Annisquam, Mass. From 1878 to 1891 the Chesapeake Zoological Laboratory of the Johns Hopkins University was established each summer at various places along the Atlantic coast under the direction of Professor Brooks. From 1886 to 1889 E. P. Allis supported a private Lake Laboratory at Milwaukee under the direction of Professor C. O. Whitman, and later under Howard Ayres.

In 1888 the Marine Biological Laboratory was established at Woods Hole, Mass., and C. O. Whitman was made director. About thirty colleges, universities and medical schools, several academies and societies, and the Carnegie Institution have contributed to the support of the laboratory by maintaining there "tables" for scientific workers. The members of the corporation are elected chiefly from those who make or have made use of the facilities of the laboratory for scientific study. They in turn elect a board of trustees, of whom there are at present twenty-six. Of these, sixteen are professors in the biological sciences in various colleges and universities, four are biologists not connected with educational institutions, and six are business men interested in the success of the laboratory. In addition there are three ex-officio members, C. O. Whitman. director of the laboratory, F. R. Lillie, assistant director of the laboratory, and A. W. Wilcox, clerk of the corporation.

Instruction and investigation are carried on at the laboratory, during the summer months, in zoology, embryology, physiology and botany. No factor has been more potent in arousing interest in biological investigation in this country. To name those who have worked at this laboratory for greater or less periods of time and have made important contributions in the field of anatomy, as well as in other fields of biological study, would be to name the great majority of the leading biologists of the country. In publications of the laboratory lists of the investigators and their contributions may be found.

In 1889 a biological laboratory was established at Cold Spring Harbor by the Brooklyn Institute of Arts and Sciences. This laboratory has been in charge successively of B. Dean, H. W. Conn, and C. B. Davenport. In 1891 the University of Pennsylvania maintained a laboratory at Sea Isle City. More recently J. S. Kingsley has established a summer laboratory near Portland, Maine, and the University of Minnesota, the University of California and Leland Stanford have established marine laboratories on the Pacific coast. The University of Nebraska, since 1899, has maintained a lake laboratory during the summer, and other institutions have similar laboratories.

Harvard University, New York University and the Bermuda Natural History Society for several seasons have offered American biologists laboratory facilities at the Island of Bermuda.

The United States Fish Commission under S. Baird offered in the seventies opportunity for scientific investigation at the Fish Commission Station at Woods Hole. It now maintains laboratories open to scientific workers at Woods Hole, Mass., Beaufort, North Carolina, and at Put-in-Bay, Ohio, on Lake Erie. Lately the Carnegie Institution has established an institution for biological research at Cold Spring Harbor. C. B. Davenport has been made director.

In many respects these various laboratories constitute our truest university biological departments. There is such a tendency to force a man to consume all of his time in teaching and routine administration in the majority of American colleges and universities that the chief part of the biological research done in this country is done in the summer and a large part at the leading marine and lake laboratories. The leading men who go serve to furnish ideas to others who want to work. The tables maintained by the Smithsonian and other institutions at the biological station at Naples, in Italy, have likewise proved a great aid to American biologists. All who have had the privilege of being there feel the deepest gratitude to Professor Dohrn and the members of his staff for their many courtesies and kindnesses.

36, (p. 101). MUSEUMS.

The American Museum of Natural History at New York under the charge of Professor Bumpus, the Field Columbian Museum at Chicago, the National Museum at Washington, the Boston Society of Natural History, the Academy of Science, the Wistar Institute of Anatomy at Philadelphia, the Agassiz Museum at Cambridge, and the Army Medical Museum at Washington should here more especially be mentioned.

Under the active leadership of Dr. M. J. Greenman, recently appointed director of the Wistar Institute, and with the hearty co-operation of General Wistar, its founder, and of the board of managers steps have been taken greatly to enlarge its scope.

"Ten of the leading American anatomists were invited to take part in a conference held at the institute on Tuesday and Wednesday, April 11 and 12, to consider with the management of the Wistar Institute the question of increasing the usefulness of the Wistar Institute to American anatomists by establishing relationship with the individual anatomists of the country, with the Associaton of American Anatomists, with the *American Journal of Anatomy* and with similar institutes abroad; and also by establishing an advisory board of anatomists of the Wistar Institute, with ten or more members, selected from the leading anatomists of the country.

The following anatomists were present at the conference:

Dr. Lewellys F. Barker, professor of anatomy, University of Chicago, Chicago, Ills.

Dr. Edwin G. Conklin, professor of zoology, University of Pennsylvania, Philadelphia, Pa.

Dr. Henry H. Donaldson, professor of neurology, University of Chicago, Chicago, Ills.

Mr. Simon H. Gage, professor of embryology, Cornell University, Ithaca, N. Y.

Dr. G. Carl Huber, professor of embryology and histology, University of Michigan, Ann Arbor, Mich.

Dr. George S. Huntington, professor of anatomy, Columbia University, New York City.

Dr. Franklin P. Mall, professor of anatomy, Johns Hopkins University, Baltimore, Md.

Dr. J. Playfair McMurrich, professor of anatomy, University of Michigan, Ann Arbor, Mich.

Dr. Charles S. Minot, professor of embryology, Harvard Medical School, Boston, Mass.

Dr. George S. Piersol, professor of anatomy, University of Pennsylvania, Philadelphia, Pa."

At this meeting the following recommendations were adopted:

"'(1) The principal object of the institute to be research and under these headings: (*a*) a chief of investigation, (*b*) research assistants or assistantships and men who shall divide their services between the museum proper and research, (*c*) technical assistants. (2) Research and materials: (*a*) research shall be in the field of neurology, (*b*) comparative anatomy and embryology. (3) Relations: (*a*) committee

recommends that the subvention of the *Journal of Anatomy* be granted, (*b*) committee be appointed to consider relations of the Wistar Institute to American anatomists, (*c*) the Wistar Institute to apply to the Association of American Anatomists for cooperation. (4) That an advisory board of ten be appointed for general purposes: (*a*) to form a sub-committee on neurology as well as other sub-committees that may be needed, (*b*) to establish relations with the committee of the International Association of Academies for Brain Investigation and with other committees for collective investigation, (*c*) the committee recommends that the board bear in mind that while the general trend of work above outlined is recommended there is no intention to advise limitation of the functions of the institute to it exclusively.

"The advisory board proceeded to appoint the following committees: on neurology and the establishment of relations with the International Association of Academies, Dr. L. F. Barker, Dr. H. H. Donaldson, Dr. F. P. Mall, Dr. J. P. McMurrich, Dr. C. S. Minot (this committee to elect its own chairman); on relations of the Wistar Institute to American Anatomists, Professor S. H. Gage, chairman, Dr. Geo. A. Piersol, Dr. G. Carl Huber; on comparative anatomy and embryology, Dr. Geo. S. Huntington, chairman, Dr. E. G. Conklin, Dr. F. P. Mall." (*Science*, May 5, 1905.)

The members of the conference have been appointed a permanent advisory board of the institute.

37 (p. 101). SOCIETIES.

The oldest of the American Scientific Societies, the American Philosophical Society, which originated from a society founded in 1743, the American Academy of Arts and Sciences, founded in 1780, the various state and municipal Academies of Science, and the medical societies of the country long afforded some means of verbal communication of anatomical discoveries and for their publication.

The great popularizing society, the *American Association for the Advancement of Science*, founded in 1848, has performed a similar service. Among its presidents two morphologists are to be found, Jeffries Wyman, 1857, C. S. Minot, 1901, and three paleontologists, Louis Agassiz, 1851, O. C. March, 1878, and E. D. Cope, 1896. At the twenty-fourth session of the society, in 1875, the association met in two sections, of which one was given up to "Natural History," with sub-sections in microscopy, anthropology, and entomology (1881). At the thirty-first session, in 1882, the society met in nine sections of which

one was devoted to "Biology," one to "Microscopy" (given up in 1885), and one to "Anthropology." Since 1892 the "Biological Section" has been divided into Zoological and Botanical Sections. In 1902 a section of physiology and experimental medicine was formed. There has never been a section devoted especially to anatomy, but numerous papers dealing with various aspects of organic structure have been presented before the various sections mentioned. Among those who have presided over the section "Biology" may be mentioned E. D. Cope, 1884, B. G. Wilder, 1885, C. S. Minot, 1890, and S. H. Gage, 1892. W. G. Farlow, who has done much to advance vegetable anatomy in this country, presided in 1887. In section "F," "Zoology," H. F. Osborn, 1893, A. S. Packard, 1898, S. H. Gage, 1899, C. B. Davenport, 1900, E. L. Mark, 1902 and 1904, and C. W. Hargitt, 1903, zoologists who have devoted much attention to morphological problems, were among those selected to preside. Among the presidents of the section "G," "Botany," there have been several who have devoted especial attention to the anatomy of plants, C. E. Bessey, 1893, L. M. Underwood, 1894, and W. G. Farlow, 1898. Of the presidents of section "H," "Anthropology," D. G. Brinton, 1887, Frank Baker, 1890, and W. H. Holmes, 1892, have all contributed toward physical anthropology.

In 1878 a growing popular interest led to the formation of the *American Microscopical Society*. Although some valuable papers have been presented before this society, there is comparatively little in its Transactions of interest to the professional anatomist.

In 1881 the Society of Naturalists of the Eastern United States was organized for the discussion of methods of investigation and instruction, laboratory technique and museum administration and other topics of interest to investigators and teachers of natural science. Membership was restricted to those who had done original work. For several years this society proved a valuable means of bringing together the leading biologists of the country once a year to discuss the various topics mentioned above. After the formation of the American Morphological Society in 1890 the Society of Naturalists finally became converted into an organization for the maintenance of a center at which numerous special societies devoted to various aspects of natural history might meet in conjunction. Among the special societies are the Association of American Anatomists, the American Morphological Society, the American Physiological Society, the American Psychological Association, the American Society of Zoologists, the Society of American Bacteriologists, the Geological Society of America, the Society for Plant Morphology and Physiology, the American Anthropological Association, the American Society of Vertebrate Paleontologists, etc. The

Society of Naturalists arranges railroad rates and holds an annual meeting and an annual dinner at which speeches devoted to some topics of the day important to biologists, are given by distinguished investigators. Since 1902 it has had Eastern and Central sections.

The increased interest in the anatomical sciences, which developed in this country during the last quarter of the nineteenth century, led in 1888 to the establishment of the *Association of American Anatomists.*

This association was formed at a meeting of the Congress of American Physicians and Surgeons at Washington, September, 1888. Among the organizers were Dr. Harrison Allen of the University of Pennsylvania; Dr. Frank Baker, Professor of Anatomy, Georgetown University; Dr. Augustus Bernays, Professor of Anatomy, the St. Louis College of Physicians and Surgeons; Dr. W. W. Gray, Microscopist, Army Medical Museum; Dr. Horace Jayne, Professor of Vertebrate Morphology, the University of Pennsylvania; Dr. D. S. Lamb, Professor of Anatomy, Medical Department, Howard University, Washington, D. C.; Mr. F. A. Lucas, Osteologist, U. S. National Museum; Dr. George McClellan, of Philadelphia; and Dr. J. Wortman, Anatomist, Army Medical Museum. The object of the society was and is "the advancement of the anatomical sciences." The first president was J. Leidy.

Among the more prominent of other early members may be mentioned E. P. Allis, H. Ayers, George Bauer, J. A. Blake, E. D. Cope, W. T. Councilman, T. Dwight, P. A. Fish, F. Baker, S. H. Gage, T. N. Gill, C. Heitzmann, C. J. Herrick, G. S. Huntington, W. W. Keen, G. T. Kemp, T. G. Lee, J. Leidy, C. S. Minot, J. P. McMurrich, O. C. Marsh, H. F. Osborn, G. A. Piersol, J. A. Ryder, W. B. Scott, F. J. Shepherd, R. W. Shufeldt, E. C. Spitzka, T. B. Stowell, B. G. Wilder, S. W. Williston, W. P. Wilson, and R. Ramsey Wright.

In 1891 there were 84 members. Of these 44 were professors and instructors in various medical schools, scarcely half a dozen of whom could properly be called scientific investigators. Ten were professors and instructors in zoology, all men of scientific attainments, five were scientists on the staff of the U. S. Museum, three were professors of geology and paleontology, two professors of botany, and the rest were variously interested in the study of the biological sciences.

In 1894 out of 300 professors and demonstrators of anatomy in the various medical schools of this country and Canada but 48 were members of the association. At the time of the last publication of a list of members of the association (1903), there were 150 members, of whom 101 were professors and instructors in medical schools. Of these about half have published scientific articles of merit. Hereafter scientific

work will be made a requirement for admission. Of the remaining 49, two are anthropologists, twelve zoologists, two botanists, twenty-five physicians and surgeons, one a pathologist, five physiologists, one a pharmacologist, and one is a maker of anatomical models. The medical departments of 42 out of 166 medical schools of the country are represented. In addition seven universities not having medical departments are represented, as well as the Field Columbian Museum, Army Medical Museum and the Philadelphia Commercial Museum.

The following table shows the geographical distribution of the members since the society was founded:

	1888.	1891.	1892.	1894.	1895.	1897.	1898.	1899.	1900.	1901.	1902.	1903
Pennsylvania	23	19	21	18	17	14	15	9	9	9	10	15
New York	12	19	22	21	24	28	40	35	39	38	35	36
Dist. Columbia	9	17	16	17	18	17	17	14	14	9	11	10
Massachusetts	8	7	7	9	9	9	9	10	9	11	13	15
Canada	3	3	4	3	4	4	5	6	6	6	6	6
Illinois	3	4	5	3	2	4	4	4	8	16	19	18
Virginia	3	3	3	2	3	5	5	5	5	4	5	5
Connecticut	2	3	2	5	5	5	5	4	3	3	4	4
California	2	1	1	1		1	1	1	1	3	4	4
Louisiana	2	2	2	2	2	2	2	2	3	2	2	2
Missouri	2	1	1	4	4	5	5	3	4	5	5	6
Colorado	1	1	1		1	1	1	1	1	0	1	1
Kansas	1	1	1	1						2	1	
Maryland	1	1		1	1		3	4	8	8	9	12
Minnesota	1	1	2	1	1	1	1	1	1	1	2	2
Michigan	1	2		1	1	1	2	2	1	2	3	4
Nebraska	1											
New Jersey	1		1	1	1						1	
New Mexico	1											
Ohio	1	2	2	4	6	5	5	5	5	4	4	4
Tennessee	1											
Texas	1	1	1	2	1	3	3	2	1	1	2	3
Wisconsin	1	1	1	1	1	1	1	2	2	2	2	2
Maine		2	2	3	3	5	5	6	6	6	7	9
Iowa		1	1	1	1							
Arizona		1	1	1	1							
West Virginia		0	1	1	1							
South Carolina			1									
Oregon			1						1			
New Hampshire					1	1	2	1	1	1	1	2
Georgia							1	1	1	1	1	1
North Carolina											1	1
Indiana												1

The presidents of the society have been, Dr. Joseph Leidy, 1888 to 1890; Dr. Harrison Allen, from 1891 to 1892; Dr. Thomas Dwight, from 1893 to 1894; Dr. Frank Baker, from 1895 to 1896; Dr. B. G. Wilder, from 1897 to 1899; Dr. George S. Huntington, from 1899 to 1903, and Dr. C. S. Minot, 1904.

Under the leadership of Professors Huntington, Huber, Gage, Mall, Minot, and other leading anatomists, the society is at present doing much to develop scientific anatomy.

The morphological direction which biology took in America during the eighties produced a large number of zoologists interested in certain

aspects of comparative anatomy who failed to find in the Anatomical Society congenial association. This was due in part to lack of acquaintance with and interest in the problems of human anatomy, and in part to the fact that a large number of the members of the Association of Anatomists were not productive investigators. A number of biologists, therefore, in 1890 founded the *American Morphological Society* for the presentation and discussion of new or important facts in the department of animal morphology and limited the membership to active contributors in that field of work. The founders of the society were, E. A. Andrews, associate professor in biology, Johns Hopkins University; Howard Ayers, late president of the University of Cincinnati; H. C. Bumpus, director American Museum of Natural History; S. F. Clarke, professor of natural history, Williams College; Dr. E. G. Gardiner, Boston, Mass.; Dr. A. Hyatt, curator, Boston Society of Natural History; F. P. Mall, professor of anatomy, Johns Hopkins University; E. L. Mark, Hersey professor of anatomy and director of the zoological laboratory, Harvard University; J. P. McMurrich, professor of anatomy, University of Michigan; C. S. Minot, professor of histology and human embryology, Harvard University; T. H. Morgan, professor of zoology, Columbia University; E. S. Morse, director of Peabody Academy of Science; H. F. Osborn, professor of zoology, Columbia University; G. H. Parker, assistant professor of zoology, Harvard University; W. M. Rankin, assistant professor of biology, Princeton University; S. H. Scudder, Cambridge, Mass.; S. I. Smith, professor of comparative anatomy, Yale University; Dr. S. Watase, Imperial University, Tokio, Japan; W. M. Wheeler, curator of invertebrate zoology, American Museum; C. O. Whitman, head-professor of zoology, University of Chicago; E. B. Wilson, professor of zoology, Columbia University; and R. Ramsey Wright, professor of biology, University of Toronto.

The presidents have been C. O. Whitman, from 1890 to 1894; E. B. Wilson, for 1894–5; E. L. Mark, for 1895–6; C. S. Minot, for 1896–7; H. F. Osborn, for 1897–8; E. G. Conklin, for 1898–9; T. H. Morgan, for 1899–0; J. S. Kingsley, for 1900–1.

After a most useful career of twelve years the society was finally, in 1902, reorganized as the American Society of Zoologists, with two branches, an Eastern and a Central. The scientific development of the Association of American Anatomists has at the same time attracted into its membership a considerable proportion of zoologists interested in anatomical problems.

In 1901 the American Paleontological Society, Section A—Vertebrata, was formed. The organization of this society gives expression to a line of scientific activity that has been prominent in America for

over a century and in which Americans have been among the world-leaders. For 1905 W. B. Scott is president and Marcus S. Farr, secretary.

38, (p. 101). JOURNALS.

Articles relating to human anatomy have always been received by the leading medical journals. The first of these was the *New York Medical Repository*, founded in 1797. Thacher (American Medical Biography) gives a list of some twenty journals established previous to 1828. Since then the number of journals which have been established and maintained for a greater or less length of time is very great. Of these various journals the *American Journal of the Medical Sciences* of Philadelphia and *The Johns Hopkins Hospital Bulletin and Reports* of Baltimore have contained numerous scientific contributions to anatomy. The Bulletin has furnished several anatomical numbers. Other medical journals have also published contributions of importance to anatomy. Among these may be mentioned the *Journal of the Boston Society of Medical Sciences*, the *Boston Medical and Surgical Journal* and the *Journal of Medical Research*, of Boston; *The New York Medical Journal*, *Journal of Obstetrics*, *Journal of Experimental Medicine*, *Journal of Mental and Nervous Diseases* and the *Journal of Neurology and Psychiatry*, of New York; the *Annals of Surgery* and *University of Pennsylvania Medical Bulletin*, of Philadelphia; and the *Journal of the American Medical Association*, of Chicago.

The *American Anthropologist* and other publications devoted to Anthropology have contained numerous articles of value on pbysical anthropology.

The publications of museums and of various learned societies, municipal, state and national, and the special publications of various educational institutions have offered opportunity for the publication of articles on anatomy. Of these the publications of the Boston Society of Natural History and the Bulletins of the Museum of Comparative Zoology at Cambridge contain the greatest number of articles on anatomical subjects, paleontology excepted.

In 1818 Professor Stilliman of Yale commenced the publication of the *American Journal of Science*. This journal for nearly a century has been a potent means of stimulating scientific research. It has, however, been devoted rather to chemistry and mineralogy than to biology.

The establishment of the *American Naturalist* by A. S. Packard, C. S. Morse, A. Hyatt and F. W. Putnam in 1867, filled a growing need of a

journal for the publication of articles by those interested in natural history. Under the editorship of Packard, Cope and Kingsley it proved of the greatest value to American biology. A considerable number of important articles on anatomical problems treated from the biological standpoint have appeared in this journal.

The swing toward morphological problems which distinguished the development of zoology in this country during the eighties led in 1887 to the establishment of the *Journal of Morphology* with C. O. Whitman as editor and E. P. Allis as co-editor and chief financial supporter. This journal did much to encourage scientific work in America and to call the attention of European biologists to the progress here being made. The expense of carrying it on proved so great that in 1900 it was discontinued. Fortunately it is announced that its publication will soon be resumed.

In 1891 C. L. Herrick established the *Journal of Comparative Neurology*. The chief work of carrying on the journal has fallen, however, upon the shoulders of his brother, C. J. Herrick, Professor of Biology, Denison University, Granville, Ohio, who has earned the gratitude of all Americans interested in scientific neurology for the aid thus given to its advance. In 1903 the scope of the journal was extended so as to include comparative psychology and R. M. Yerkes and H. S. Jennings became associated with C. J. Herrick and O. S. Strong in its management.

Several journals on microscopy have been published in this country, most of them of a very "popular" nature. The most important of them, the *American Monthly Microscopical Journal*, contains some articles of interest to professional anatomists. In 1898 the *Journal of Applied Microscopy* was established at Rochester with the support of the Bausch & Lomb Optical Company. This journal was devoted more especially to microscopic technique and published a considerable number of valuable articles on this subject. Owing to the expense involved in maintaining the journal it was discontinued in 1903.

In 1899 the *Biological Bulletin* was established to serve primarily as a place for publication of brief articles on work done at the Marine Biological Laboratory at Woods Hole. It has been edited by the Director and Staff of the Laboratory and since 1902 has been under the active editorship of F. R. Lillie. Much of the work there published is based on studies of organic structure.

In 1901 the *American Journal of Anatomy* was established by G. S. Huntington, F. P. Mall and C. S. Minot, with whom are associated as editors, L. F. Barker, T. Dwight, S. H. Gage, G. C. Huber, G. S. Piersol, J. P. McMurrich and J. L. Flint. The business management of the jour-

nal is in the hands of the Secretary of the Editorial Board, Dr. H. Mc E. Knower. Many generous friends have aided the editors in establishing an endowment fund for the journal. It has assumed a high character and has been classed by Waldeyer (Merkel–Bonnet, Ergebnisse, 1903) as of a merit equal to that of the better European journals. The journal is the official organ of the Association of American Anatomists.

In 1904 the *Journal of Experimental Zoology* was established with the following editors: W. K. Brooks, W. E. Castle, E. G. Conklin, C. B. Davenport, R. G. Harrison, H. S. Jennings, J. Loeb, T. H. Morgan, G. H. Parker, C. O. Whitman, and E. B. Wilson. R. G. Harrison is the managing editor. This journal is the natural expression of the great activity which has been shown of recent years by Americans, especially those mentioned above as editors, in the field of experimental morphology. It marks a new step in advance.

Mention should be likewise made of the fact that C. B. Davenport is one of the three active editors of the new journal, *Biometrica,* published in London. This journal deals with statistical methods of study of biological problems.

39, (p. 103). SPECIAL HUMAN ANATOMY.

History of anatomy: Numerous addresses have been published by Americans. Of these W. W. Keen's "Sketch of the Early History of Practical Anatomy," Philadelphia, 1874, is of special value because of the light it throws on the conditions in the English schools of the eighteenth century from which the American schools arose. E. M. Hartwell has likewise made a good contribution in his "The Study of Human Anatomy." (Studies from the Biological Laboratory, Baltimore, 1881.) A most valuable account of the history of anatomy in America is to be found in W. W. Keen's "The Philadelphia School of Anatomy" (1875). E. M. Hartwell also has published a valuable paper in his "Hindrances to Anatomical Study in the United States" (Annals of Anatomy and Surgery, Brooklyn, 1881). Carson's History of the Medical Department of the University of Pennsylvania may likewise be consulted with advantage.

Text-books: A considerable number of text-books on descriptive human anatomy have been compiled by Americans but none of them have the popularity in this country of the leading English anatomies and none, so far as I am aware, have been used outside of the United States. Among the more recent authors may be mentioned H. Allen, Human Anatomy (1882); J. Leidy, Human Anatomy (1889); Brock-

way and O'Malley, Human Anatomy (1892); F. H. Gerrish, Text-Book of Anatomy by American Authors (2d ed., 1902).

L. F. Barker has translated into English Spalteholz's valuable Hand Atlas of Human Anatomy (1901–1903).

Of *manuals of dissection* may be mentioned those of F. D. Weisse (1886, Practical Human Anatomy, a book of great merit and originality), A. Hewson (1893), C. Heath (1893), W. A. Campbell (1895), I. S. Haynes (1896), W. T. and C. D. Eckley (1903), and the recent excellent "Laboratory Manual of Anatomy" by L. F. Barker (1904).

Articles on methods of teaching and study have within recent years been published by H. Allen (1891), F. Baker (1884, 1887), C. R. Bardeen (1900), L. F. Barker (1901), A. D. Bevan (1892), W. D. Carr (1892), T. Dwight (1890, 1891, 1895), F. H. Gerrish (1895), G S. Huntington (1898, 1899, 1901), C. M. Jackson (1901), W. W. Keen (1881), W. Keiler (1894), F. P. Mall (1895, 1899, 1905), G. H. Minks (1885), J. P. McMurrich (1899), W. Osler (1894), W. Pepper (1894), A. Primrose (1894), R. Rayburn (1891), W. Shields (1894), and R. J. Terry (1904).

Text-books on surgical anatomy have been written by J. B. Deaver (1900–1904), and G. McClellan (1892), on clinical anatomy by D. N. Eisendrath (1903), and on artistic anatomy by G. McClellan (1901). T. Dwight published in 1881 "The Frozen Sections of a Child." Many of the more recent text-books on special branches of surgery have excellent chapters on the anatomy of certain areas of the body. J. W. Williams' "Obstetrics" and H. A. Kelley's "Gynecology" may here especially be mentioned. Many articles on surgical operations have likewise contained good accounts of the anatomy of special regions.

Articles on preparation, preservation and use of anatomical material and specimens have been written by J. L. Flint (1905), A. Hewson (1892), E. W. Holmes (1897), W. W. Keen (1873), W. Keiler (1892), A. T. Kerr (1901), F. P. Mall (1896), R. Park (1882), R. W. Roosevelt (1889), R. J. Terry (1902), and several others. (See especially F. P. Mall, Johns Hopkins Bulletin, May–June, 1896, and 1905; and Committee Assn. Am. Anat., Science, vol. 3, 1896.)

Papers on the anatomy and the frequency of structural variation of the various organic systems in man have been written by the following:

Skeletal system: H. Allen, C. R. Bardeen, F. Brockway, J. D. Bryant, G. R. Butler, E. B. Clinton, E. R. Corson, T. Dwight, A. Hrdlicka, P. P. Lardlaw, J. Leidy, R. W. Lovett, F. Mall, J. H. Packard, C. A. Parker, F. J. Shephard, E. A. Taylor, R. T. Terry, G. Walker, J. A. Wyeth.

Muscular system: H. Allen, E. A. Ballock, F. Baker, H. A. Christian,

Clarkson, J. D. Craig, J. B. Deaver, T. Dwight, W. S. Forbes, A. Harrison, G. S. Huntington, W. W. Keen, W. G. Lee, J. Leidy, W. H. Lewis, J. P. McMurrich, F. J. Shephard, W. H. White, J. S. Wight, and T. Wilson.

Vascular system: F. Baker, R. B. Bean, W. Browning, J. D. Bryant, W Coleman, J. B. Deaver, T. Dwight, J. M. Hitzrot, W. Keiller, and F. J. Shephard.

The blood: L. F. Barker, G. C. Huber, F. T. Lewis, G. T. Kemp, C. S. Minot, W. Moser, W. Osler, and M. C. White.

Genito-urinary system: M. Brödel, V. Carnett, J. G. Clark, H. C. Coe, T. S. Cullen, G. C. Huber, G. L. Hunner, D. S. Lamb, E. Martin, C. S. Minot, J. P. Morse, G. A. Piersol, G. Walker, J. W. Webster, and J. W. Williams.

Alimentary tract and abdomen: C. B. Ball, R. B. Bensley, J. A. Blake, C. S. Coakley, C. H. Harvey, A. W. Hewlett, E. Hodenpyl, G. H. Huntington, C. N. Johnson, W. B. Johnston, D. S. Lamb, F. P. Mall, T. H. Manley, R. O. Moody, D. G. Revell, Byron Robinson.

Respiratory tract and thorax: H. J. Bigelow, J. A. Blake, W. T. Councilman, F. Delafield, G. S. Huntington, W. W. Keen, D. D. Lewis, W. S. Miller, H. J. Prentiss, J. W. Roosevelt, C. Seiler, and E. A. Spitzka.

The skin and glands: T. S. McGillienday, G. C. Huber, W. Keiler, C. S. Minot, R. B. Morrison, H. H. Wilder.

Nervous system: Donaldson's "Growth of the Brain" (1895), contains much useful information about the adult as well as the growing brain. R. H. Whitehead has written a small book on "The Anatomy of the Brain." M. Allen Starr, O. S. Strong and E. Leaming have published an atlas of nerve cells (1897). F. R. Sabin (1901) has contributed a standard "Atlas of the Medulla and Midbrain," L. F. Barker (1899), a text-book on "The Nervous System and Its Constituent Neurons," and H. C. Gordinier (1899), a text-book on the "Gross and Minute Anatomy of the Central Nervous System."

Among those who have contributed special articles on the peripheral nervous system of man may be mentioned: C. R. Bardeen, L. F. Barker, C. J. Blake, H. Cushing, C. L. Dana, A. W. Elting, C. E. Ingebert, J. P. McMurrich, Newton, W. F. Norris, M. Allen Starr, J. Wallace, and J. F. Walsh.

Among those who have contributed to the anatomy of the human central nervous system may be mentioned: R. B. Bean, H. J. Berkley, J. E. Blake, W. Browning, Brown-Sequard, A. Church, C. L. Dana, F. X. Dercum, H. H. Donalson, H. A. Fowler, B. B. Gallaudet, E. Goodall, Alice Hamilton, G. S. Huntington, F. P. Mall, McLane Hamilton, E. L.

Mellus, A. Meyer, C. K. Mills, F. R. Sabin, B. Sachs, M. G. Schlapp, E. C. Seguin, W. G. Spiller, E. A. Spitzka, E. C. Spitzka, M. Allen Starr, O. S. Strong, H. D. Thompson, W. H. White, B. G. Wilder, and W. L. Worcester.

Development: The following have published papers on human embryology: C. R. Bardeen, J. M. Berry, J. L. Bremer, M. Broedel, J. G. Clark, S. P. Gage, R. G. Harrison, W. F. Hendrickson, F. Hinman, C. M. Jackson, W. W. Keen, W. H. Lewis, J. B. MacCallum, F. P. Mall, A. W. Meyers, C. S. Minot, R. M. Pearce, A. G. Pohlman, F. R. Sabin, H. D. Schmidt, G. L. Streeter, M. T. Sudler, H. E. Walter, R. Weil, E. V. Wilcox.

The following are a few among the many who have published papers describing cases of marked abnormality in development: H. Allen, F. H. Allen, F. Baker, W. E. Baldwin, E. E. Bancroft, B. Bigelow, R. L. Bowles, G. Bull, J. C. Carson, J. G. Clark, H. C. Coe, J. D. Craig, M. H. Dean, T. Dwight, L. Freeman, W. J. Fairchild, G. H. Fisher, C. M. Green, H. D. Hamilton, R. G. Harrison, L. Hektoen, B. C. Hirst, G. A. Hamman, W. T. Howard, T. Hubbard, J. Kaufmann, C. M. Kennedy, F. E. Lloyd, J. W. S. McCullough, A. McDiarmid, W. A. MacFarlane, W. G. MacCallum, J. M. Mathews, W. F. Milroy, W. Moser, A. S. Morton, T. H. Myers, W. P. Northrup, J. C. Oliver, W. Osler, D. L. Paine, R. Park, C. B. Penrose, J. C. Perry, G. A. Piersol, A. Primrose, A. Prince, R. H. Sayre, G. G. Sears, E. T. Shelley, G. E. Shoemaker, A. J. Smith, M. M. Smith, L. B. Snow, W. A. Sprigg, R. T. Terry, J. S. Thatcher, P. Thorndike, C. W. Townsend, W. S. Wadsworth, W. H. White, H. H. Wilder, H. S. Williams, T. Wilson, R. H. Wood.

Variation: The following have made studies of variation in human structure from the standpoint of age, sex and race: H. Allen, C. R. Bardeen, R. B. Bean, H. G. Beyer, F. Boas, H. P. Bowditch, D. G. Brinton, G. A. Dorsey, T. Dwight, A. W. Elting, B. A. Gould, W. W. Hastings, E. Hitchcock, A. Hrdlicka, F. P. Mall, W. D. Matthews, W. T. Porter, W. Z. Ripley, F. Russell, D. K. Shute, E. A. Spitzka, F. Tuckerman, G. M. West, H. H. Wilder.

W. H. Holmes, J. Leidy, W. D. Whitney, and others, have described supposedly ancient human bones.

B. G. Wilder has long advocated an original and simplified system of nomenclature for the central nervous system. He has gained a few partial adherents to this. L. F. Barker has had more success in introducing into use in this country the new nomenclature adopted by the German Society of Anatomists.

The above lists of names, like those of the following notes, have been derived primarily from the general indices of Schwalbe's Anatomische

Jahresberichte for the years 1872-1901. Some other names have been added but the lists by no means include the names of all Americans who have contributed articles of greater or less merit on the various subjects mentioned. Classification of papers is likewise difficult. Those who have been classed as contributing to one subject, because of the titles of their papers, often have in reality contributed to several related fields of knowledge. It is believed, however, that the lists mentioned in this and the following notes may prove of interest because they show what fields of anatomy have been most cultivated by Americans and the considerable numbers that have worked in certain fields.

40, (p. 108). COMPARATIVE ANATOMY OF VERTEBRATES.

W. H. Howell has written a descriptive anatomy of "The Dog" (1888), Reighard and Jennings have written one on "The Cat" (1901), Wilder and Gage on the cat in "Anatomical Technology" (1882), and H. Jayne an extensive description of the skeleton of the cat in "Mammalian Anatomy as Preparation for Human and Comparative Anatomy" (Philadelphia, 1898). A. Davison and Gorham and Tower have also published text-books on "The Cat." J. M. Fadyeau has published (1904) an "Anatomy of the Horse, a Dissector's Guide." R. W. Shufeldt (1890), has published a book on the "Myology of the Raven." A. Wiley has written a book on Amphioxus and the life history of the vertebrates (1894). J. S. Kingsley's Vertebrate Zoology (1899), is an interesting treatise on comparative anatomy and embryology. H. N. Martin and W. A. Moale published early in the eighties, useful guides for dissecting the turtle, the pigeon and the rat. Special mention should be made of G. H. Huntington's "Anatomy of the Peritoneum" (1903), an extensive comparative study.

Until within the last twenty-five years the bulk of the work done in gross comparative anatomy in America has been from the point of view of specific characteristics and genetic relationships. Among the more recent contributors to this field of the comparative vertebrate anatomy may be mentioned: A. Agassiz, L. Agassiz, H. Allen, E. P. Allis, B. A. Bensley, G. Baur, H. C. Chapman, J. D. Dana, B. Dean, C. H. Eigenman, H. H. Field, W. K. Gregory, D S. Jordan, T. Gill, O. P. Hay, J. S. Kingsley, F. A. Lucas, E. L. Mark, J. P. Moore, E. S. Morse, H. F. Osborn, W. Patten, A. M. Reese, J. A. Ryder, A. E. Shipley, R. W. Shufeldt, R. J. Terry, J. K. Thatcher, B. G. Wilder.

In the field of vertebrate paleontology Americans have been unusually active for a century. Among the more recent workers are: C. J.

Adams, C. Austin, G. Baur, E. W. Claypole, W. B. Clapp, E. D. Cope, B. Dean, C. R. Eastman, D. G. Elliot, M. S. Farr, T. Gill, J. B. Hatcher, O. P. Hay, A. Hyatt, C. R. Keyes, W. C. Knight, J. Leidy, F. B. Loomis, R. S. Lull, F. A. Lucas, O. C. Marsh, W. D. Matthew, J. C. Merriam, E. S. Morse, H. F. Osborn, W. Patten, E. S. Riggs, W. B. Scott, R. W. Shufeldt, C. H. Sinclair, A. Stewart, C. Walcott, S. W. Williston.

Comparative study of the gross anatomy of various organic systems of various vertebrates has been made by the following: H. Allen, E. P. Allis, H. Ayres, F. Baker, J. L. Bremer, A. L. Bruner, C. Carmalt, E. J. Claypole, C. B. Davenport, F. K. Davis, A. Davidson, B. Dean, F. Dercum, F. Dexter, C. L. Edwards, C. H. Eigenmann, S. H. Gage, T. H. Gill, W. A. Hilton, Ida Hyde, G. S. Hopkins, G. S. Huntington, C. M. Jackson, H. Jayne, G. E. Johnson, J. S. Kingsley, H. M. Lane, C. F. W. McClure, J. P. McMurrich, W. S. Miller, R. O. Moody, E. S. Morse, E. F. Muhse, Florence Mayo, G. H. Parker, W. E. Ritter, F. J. Shephard, J. R. Slonaker, F. Smith, C. F. Sylvester, F. W. True, H. H. Wilder, S. R. Williams, I. S. Workman.

Contributions to comparative neurology are spoken of specially in note 44, p. 202.

The following Americans have added to our knowledge of the microscopic structure of vertebrate organs: R. R. Andrews, C. R. Bardeen, R. R. Bensley, W. J. Calvert, B. A. Cohoe, Lydia M. DeWitt, G. Eisen, J. M. Flint, S. H. Gage, H. R. Harrington, W. F. Hendrickson, G. S. Hopkins, G. L. Houser, G. C. Huber, B. F. Kingsbury, P. Kyes, F. P. Mall, W. S. Miller, C. S. Minot, T. W. Montgomery, E. L. Opie, R. M. Pearce, D. G. Revell, F. Schmitter, G. Walker, A. S. Warthin, F. G. White. For text-books on this subject see note 41.

(See concluding paragraph, note 39, p. 197.)

41, (p. 110). COMPARATIVE HISTOLOGY.

T. E. Satterthwaite in 1882 edited a good manual of histology by American authors. References to American literature are here given. T. C. Prudden (1888), G. A. Piersol (1893), and E. K. Dunham (1900), have successfully written popular text-books on this subject. J. S. Ferguson has recently brought out another (1905). J. B. MacCallum (1902) has translated with annotations the Histology and Microscopic Anatomy written by L. Szmonowicz, and G. C. Huber (2nd ed., 1904), that of Boehm and von Davidoff. S. H. Gage and B. F. Kingsbury have published a laboratory guide for vertebrate histology (1900).

Among the many contributions on the subject of the structure of

vertebrate tissues may be mentioned those of: A. Agassiz, B. M. Allen, R. R. Andrews, C. R. Bardeen, L. F. Barker, H. P. Bowditch, R. H. Chittenden, G. Eisen, A. C. Eycleshymer, J. M. Flint, S. H. Gage, S. P. Gage, I. M. Green, C. Heitzmann, A. E. Hertzler, W. H. Howell, G. C. Huber, A. B. Macallum, J. B. MacCallum, W. G. MacCallum, F. P. Mall, W. S. Miller, C. S. Minot, W. Osler, J. A. Ryder, H. D. Schmidt, A. P. Matthews, C. Sihler, F. Schmitter, T. E. Satterthwaite, W. H. Welch, and M. C. White.

Those who have contributed to the histology of the nervous system are mentioned in Note 44, p. 202.

There have been fewer real contributions to microscopic technique than would have been expected from a nation so inventive as the American. Text-books on histological technique have been written by I. Hardesty, C. O. Whitman, S. H. Gage, and others. A number of more or less useful technical methods and devices have been brought out by the following workers: C. R. Bardeen, H. J. Berkeley, C. E. Bessey, H. C. Bumpus, T. Cullen, U. O. Cox, A. C. Eycleshymer, J. M. Flint, G. C. Freeborn, S. H. Gage, H. R. Gaylord, I. Van Gieson, I. Hardesty, A. F. Harris, C. J. Herrick, A. G. Hoen, G. C. Huber, F. M. MacFarland, F. B. Mallory, A. Meyer, C. S. Minot, V. A. Moore, B. D. Myers, C. A. Oliver, G. H. Parker, J. W. Roosevelt, C. Sihler, J. R. Slonaker, G. L. Streeter, R. Tolles, J. C. Webster, W. F. Whitney, W. M. Mac Woodworth, J. H. Wright.

(See concluding paragraph, Note 39, p. 197.)

42, (p. 111). CYTOLOGY.

The American literature on the cell is well treated in Wilson's text-book, "The Cell in Development and Inheritance" (1900).

Of those who have contributed papers on the more general features of the cell and the cell theory of structure, mention may be made of E. A. Andrews, G. F. Andrews, G. N. Calkins, C. M. Child, E. G. Conklin, H. E. Crampton, L. I. Dublin, A. C. Eycleshymer, K. Foot, M. F. Guyer, H. P. Johnson, B. F. Kingsbury, A. A. Lawson, F. R. Lillie, R. S. Lillie, A. B. MacCallum, E. L. Mark, A. P. Matthews, C. E. McClung, A. D. Mead, C. S. Minot, T. H. Montgomery, T. H. Morgan, W. S. Sutton, C. O. Whitman, and E. B. Wilson.

C. Heitzmann and C. O. Whitman have contended strongly against the adequacy of the cell theory of development.

The following botanists have made important contributions to the knowledge of the structure of plant cells and especially of cell divi-

sion: C. E. Allen, F. M. Andrews, G. F. Atkinson, D. H. Campbell, W. A. Cannan, C. J. Chamberlain, B. M. Davis, T. C. Frye, B. B. Griffin, R. A. Harper, D. S. Johnson, A. A. Lawson, F. M. Lyon, D. M. Mottier, W. J. V. Osterhout, J. B. Overton, E. W. Olive, W. A. Setchell, J. H. Shaffner, F. L. Stevens, R. Thaxter, C. O. Townsend, and H. J. Webber.

(See concluding paragraph, note 39, p. 197.)

43, (p. 111). EMBRYOLOGY OF VERTEBRATES.

Several text-books have been written on this subject by Americans. Foremost stands C. S. Minot's "Human Embryology" (1892), which is essentially a treatise on comparative vertebrate embryology. Minot's "Bibliography of Vertebrate Embryology" (1893), is also of the greatest help to workers in that field. Minot has recently (1903) published a "Laboratory Text-book of Embryology," based on the pig. J. P. McMurrich (1903) has written a good text-book on "Human Embryology," from the standpoint of comparative anatomy. E. L. Mark (1893) has translated Hertwig's "Embryology." J. C. Heisler (1899) has written a text-book on "Human Embryology." T. H. Morgan has published a valuable book on the "Development of the Frog's Egg" (1897). E. B. Wilson's "The Cell" contains much information about the sex-cells and fertilization. The atlas of the fertilization and karyokinesis of the ovum by Wilson and Leaming is a fine contribution. F. R. Lillie (1904) has written a useful laboratory outline guide on the embryology of the chick and pig. A. M. Reese has likewise written a college text-book on vertebrate embryology.

Among those who have contributed to the subject of formation of the sex-cells, fertilization and cleavage in animals are: A. Agassiz, L. Agassiz, E. A. Andrews, G. F. Andrews, F. W. Bancroft, E. R. Boyer, E. W. MacBride, Martha Bunting, G. N. Calkins, A. J. Carlson, W. E. Castle, C. M. Child, E. G. Conklin, A. M. Claypole, L. Dublin, C. H. Eigenmann, G. Eisen, A. C. Eycleshymer, G. W. Field, K. Foot, M. F. Guyer, C. W. Hargitt, B. N. Harper, E. H. Harper F. H. Herrick, M. Hold, H. S. Jennings, H. B. Johnson, E. O. Jordan, H. D. King, B. F. Kingsbury, J. S. Kingsley, C. A. Kofoid, T. G. Lee, G. Lefevre, F. R. Lillie, C. E. McClung, J. H. MacGregor, W. A. MacFarland, E. L. Mark, A. D. Mead, C. S. Minot, W. H. Moenkhaus, T. H. Montgomery, J. P. Moore, T. H. Morgan, J. P. Munson, H. F. Osborn, E. F. Phillips, A. M. Reese, J. A. Ryder, J. E. Reighard, W. B. Scott, E. G. Spaulding, W. S. Sutton, S. Watase, A. W. Weyse, W. M. Wheeler, R. G. Whitehead, C. O. Whitman, E. V. Wilcox, C. B. Wilson, H. V. Wilson, F. A. Woods, and N. Yatsu.

Among those who have contributed papers on specific characteristic structural differentiation in various classes of vertebrates are: A. Agassiz, L. Agassiz, H. Allen, C. M. Clapp, H. J. Clark, S. F. Clarke, B. Dean, C. H. Eigenmann, A. C. Eycleshymer, H. Fox, E. H. Gregory, Jr., E. O. Jordan, P. R Hoy, W. E. Kellicott, J. S. Kingsley, F. D. Lambert, F. R. Lillie, E. W. MacBride, J. H. McGregor, E. L. Mark, T. H. Morgan, H. Orr, F. Peebles, J. E. Reighard, H. J. Rice, W. H. Ritter, J. A. Ryder, L. V. Sampson, W. B. Scott, F. B. Summer, L. Wallace, C. O. Whitman, S. R. Williams, H. V. Wilson, J. Wyman.

The foetal membranes have been studied among others by: H. Ayres, T. G. Lee, F. R. Lillie, F. P. Mall, C. S. Minot, H. F. Osborn, and J. A. Ryder.

Among those who have contributed to the study of comparative vertebrate organo-genesis and histogenesis are: B. M. Allen, H. Ayres, C. R. Bardeen, J. M. Berry, E. R. Boyer, J. L. Bremer, W. K. Brooks, J. G. Clark, S. F. Clarke, H. E. Crampton, A. Davidson, F. Dexter, A. C. Eycleshymer, C. H. Eigenmann, H. H. Field, J. M. Flint, H. Fox, S. H. Gage, S. P. Gage, R. W. Hall, R. G. Harrison, M. Hempstead, W. F. Hendrickson, C. Hill, D. C. Hilton, W. A. Hilton, A. T. Holbrook, O. P. Hay, W. H. Howell, G. C. Huber, D. Hunt, C. M. Jackson, J. B. Johnson, E. O. Jordan, J. S. Kingsley, A. B. Lamb, F. T. Lewis, F. R. Lillie, E. W. MacBride, J. B. MacCallum, F. P. Mall, A. M. Miller, W. S. Miller, C. S. Minot, T. H. Morgan, H. V. Neal, H. W. Norris, H. F. Osborn, G. H. Parker, F. Peebles, G. A. Piersol, J. B. Platt, G. C. Price, M. A. Reed, R. M. Reese, M. J. Ross, J. A. Ryder, F. R. Sabin, L. V. Sampson, T. E. Satterthwaite, H. Sewell, A. M. Spurgon, R. M. Strong, E. Taylor, G. H. Tozier, A. H. Tuttle, J. Warren, R. G. Whitehead, and H. V. Wilson.

(See concluding paragraph, Note 38, p. 197.)

44, (p. 112). COMPARATIVE NEUROLOGY.

Text-books dealing with the comparative anatomy of the nervous system have been written by H. H. Donaldson, "The Growth of the Brain" (1895), and L. F. Barker, "The Nervous System" (1899).

The following have contributed articles relating to the comparative gross and microscopic anatomy and development of the central nervous system of vertebrates: H. Ayers, Jessie Allen, W. S. Baer, W. Barnes, J. H. Bawden, Brill, W. P. Carr, B. Clark, T. E. Clarke, H. C. Chapman, S. V. Cleavenger, G. C. Davenport, P. M. Dawson, F. Dexter, H. H. Donaldson, A. C. Eycleshymer, P. A. Fish, Alice Hamilton, G. M. Hammond, C. J. Herrick, C. L. Herrick, J. B. Johnston, B. F. Kingsbury, J. S.

Kingsley, W. W. Lesem, W. A. Locy, J. Loeb, S. D. Ludlum, H. T. Marshall, J. J. Mason, F. W. McClure, E. L. Mellus, A. Meyer, H. V. Neal, I. Nakagawa, H. F. Osborn, Pemberton, W. F. Porter, E. E. Ranney, S. W. Ranson, P. E. Sargent, E. A. Spitzka, E. C. Spitzka, B. B. Stroud, E. A. Taylor, B. G. Wilder.

The following have written papers on the structure, distribution and development of the peripheral nervous system: W. C. Ayres, C. R. Bardeen, E. A. Birge, M. A. Bowers, H. E. Cogher, Lydia M. DeWitt, E. H. Dunn, H. Fox, H. A. Green, R. G. Harrison, C. J. Herrick, W. H. Howell, G. C. Huber, G. L. Houser, J. S. Kingsley, A. J. Lanterman, W. A. Locy, H. V. Neal, C. W. Prentiss, J. J. Putnam, H. D. Schmidt, T. B. Spence, G. L. Streeter, O. S. Strong, T. B. Stowell and F. C. Waite.

The following have studied more particularly the finer structure of the nerve cell: L. F. Barker, H. J. Berkley, U. Dahlgren, I. Herdesty, S. Hatai, C. F. Hodge, G. L. Houser, G. C. Huber, C. F. W. McClure, A. Meyer, F. B. Mallory, Margaret L. Nickerson, S. Paton, W. C. Prentiss, P. Sargent, M. Allen Starr and O. S. Strong.

The following have contributed to the knowledge of nerve endings: E. P. Allis, Jr., H. J. Berkley, F. S. Bunker, G. E. Coghill, L. M. DeWitt, G. C. Huber, M. L. Nickerson, C. Sihler, A. L. Treadwell, and J. H. Wilson.

The following have studied the finer structure of the eye: B. M. Allen, W. C. Ayers, E. L. Berger, C. H. Eigenmann, D. Hunt, F. P. Mall, B. D. Myers, G. A. Piersol, R. L. Randolph, J. R. Slonaker.

The following have studied the comparative anatomy and the development of the ear: H. Ayers, L. Howe, D. Hunt, J. S. Kingsley, F. P. Mall, A. D. Morrill, H. W. Norris, G. E. Shambaugh, T. B. Spence, A. H. Tuttle.

The following have contributed papers on the organs of smell and taste: H. H. Bawden, A. Hamilton, and F. Tuckerman.

The following have written on neurological technique; H. J. Berkley, I. Van Gieson, I. Hardesty, C. J. Herrick, G. L. Houser, G. C. Huber, and F. B. Mallory.

(See concluding paragraph, Note 39, p. 197.)

45, (p. 113). EXPERIMENTAL MORPHOLOGY.

C. B. Davenport has written a text-book on "Experimental Morphology" (1897–99), J. Loeb, one on physiological morphology (1891–2), and T. H. Morgan, one on "Regeneration" (1901).

Experimental studies on the formative capacity of various parts of

the ovum have been conducted by: E. G. Conklin, H. E. Crampton, F. R. Lillie, J. Loeb, T. H. Morgan, F. Peebles, E. B. Wilson, N. Yatsu, and C. Zeleny.

The power of regeneration in invertebrates and the factors concerned have been investigated by: C. R. Bardeen, E. E. Bickford, A. M. Boring, C. M. Child, W. C. Curtis, C. B. Davenport, S. E. Davis, S. Flexner, G. L. Hargitt, C. W. Hargitt, A. P. Hazen, V. L. Kellogg, H. D. King, G. Lefevre, F. R. Lillie, J. Loeb, T. H. Morgan, F. Peebles, H. W. Rand, H. Randolph, M. A. Reed, H. T. Rowley, N. M. Stevens, H. F. Thatcher, E. W. Towle, J. Van Duyne, C. O. Whitman, E. B. Wilson, C. Zeleny.

The effects of altering the chemical media surrounding ova have been studied by: G. Bullot, C. B. Davenport, G. C. Davenport, M. H. Fisher, S. J. Hunter, G. Lefevre, W. H. Lewis, F. R. Lillie, R. S. Lillie, J. Loeb, A. P. Mathews, W. W. Norman, A. L. Treadwell.

The effects of physical agents acting on developing organisms, by: C. R. Bardeen, H. Baetjer, C. B. Davenport, C. L. Edwards, P. S. Gilman, A. W. Greeley, J. Loeb, S. J. Meltzer.

Regeneration in vertebrates has been studied by: Baer, Dawson and Marshall, E. F. Byrnes, H. C. Cushing, R. G. Harrison, W. H. Howell and G. C. Huber, W. H. Lewis, F. P. Mall, T. H. Morgan, R. L. Randolph, S. W. Ranson and E. W. Towle.

The effects of transplantation of tissues and grafting in vertebrates have been studied by: R. G. Harrison, H. McE. Knower, W. H. Lewis, L. Loeb, F. P. Mall, T. H. Morgan, R. T. Morris, G. F. Shrady, W. H. White.

The effects of physiological activity on cell structure have been investigated by: A. J. Carlson, P. K. Gilman, and C. F. Hodge. The effects of starvation on the developing nervous system of the rat have been studied by H. Hatai, and the effects of special feeding, exercise and similar phenomena are now being studied in Professor Donaldson's laboratory. (See H. Donaldson, Human Anatomy, Science, Feb. 6, 1905.)

(See concluding paragraph, Note 39, p. 197.)

46, (p. 116). VARIATION.

C. B. Davenport (2d ed., 1904) has published a valuable book on statistical methods.

Statistical studies of variation in animals have been made by: C. C. Adams, E. T. Brewster, H. C. Bumpus, W. E. Castle, H. E. Crampton, C. B. Davenport, G. C. Davenport, C. H. Eigenmann, W. L. W. Field, F. E.

Lutz, W. J. Moenkhaus, G. H. Parker, J. T. Peck, M. E. Smallwood, R. M. Strong, C. O. Whitman, S. R. Williams, and R. M. Yerkes.

Breeding experiments on a large scale have been conducted by: A. G. Bell, W. E. Castle, H. E. Crampton, C. B. Davenport, Isabel McCracken, W. L. Tower, and C. O. Whitman.

In addition many valuable studies of breeding in its practical aspect have been carried on at the experimental laboratories of the agriculture stations.

(See concluding paragraph, Note 39, p. 197.)